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There is nothing so powerful as truth, often nothing so strange.
—Daniel Webster

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXV MAY, 1935 WHOLE NO. 304

A SCIENCE EXERCISE

BY BERTHA M. PARKER
University Elementary School, Chicago, Illinois

It goes without saying that one learns by teaching others. One of the most effective devices in the teaching of elementary science is the giving of a program based on the content of a unit to a class which has not studied the unit. Such a program gives each person who participates in it an opportunity to react in his own fashion to some portion of the subject matter of the unit and to clarify his thinking about that bit of subject matter. Of course, the ability to speak convincingly to an audience is in itself a desirable learning product.

The objection to the usual type of assembly exercise is that it does not give all members of a class, if the class is so large that it meets in two or more groups, an opportunity to take part. The author has found the variation of an assembly exercise described in the following paragraphs a very satisfactory type of summary exercise.

At the conclusion of the unit each group which has studied the unit invites a lower grade group to come to the science room at some regular science period. In preparation for the exercise to be given, each child chooses a topic about which he will talk or an experiment which he will perform. Usually the choosing is done in this way: The children suggest possible topics and demonstration experiments. The list of suggestions is written on the board, and each suggestion is numbered. If the program as the children first plan it is not well-rounded, the teacher may lead the class to make additional suggestions. Then each child

draws from a box a slip of paper which has a number on it. The number is not the number of the talk nor the experiment for which the child is to be responsible; it tells the place he has in the order of choosing a part in the program. For example, the child who draws "1" has first choice of all the suggestions listed. In so far as it is possible, each child is allowed to choose the topic or experiment he prefers.

The children assemble the apparatus they need and think through the short talks they will give. Then the remainder of the group acts as audience while each member of the group in turn tries out his part in the program. Suggestions for improvement are made.

On the day the exercise is to be given, the tables of the science room are arranged in a hollow square. When the visiting group arrives, the children in it are distributed among the various tables. Each member of the science group begins at once his talk or demonstration for the visitors at his table. The members of the visiting class move from table to table, and the members of the science group repeat their talks and experiments until each visitor has seen and heard every part of the program.

The following list of suggestions is the one made out by a group which recently finished a unit on air pressure. Notice that every talk involved the showing of and, in most cases, the manipulation of materials. Every child was urged to make clear what the experiment he was performing or the materials he was showing had to do with air pressure.

1. Try to pour water into a flask through a thistle tube inserted in a rubber stopper in the neck of the flask.
2. Show air pressure with an air pump, a bladder glass, and a piece of sheet rubber.
3. Blow water out of a bottle inverted in a pan of water. Show diagram of a diving bell and a caisson.
4. Show how a siphon works. Use both a rubber siphon and a glass siphon.
5. Show three siphons in a row.
6. Show a lift pump.
7. Show how pipettes work.
8. Show how rubber suction darts can be used to pick up a plate of glass.
9. Use a piece of paper to hold the water in a inverted bottle full of water.

10. Try to drink water from a test tube through a glass lemonade straw inserted in a one-holed rubber stopper in the neck of the test tube.
11. Make air pressure push an egg into a milk bottle. Blow the egg out.
12. Show Magdeburg hemispheres.
13. Show a siphon which may be started by blowing.
14. Show how a little bottle may be made to stick to your tongue.
15. Show a balloon which has been pushed into a flask by air pressure.
16. Show that, if a bottle is inverted over a burning candle standing in a pan of water, the water will rise in the bottle when the candle goes out.
17. Show a fountain in a bottle.
18. Show a dip tube.
19. Show mercury and a mercury barometer.
20. Show a recording barometer.

The lower grade children enjoy such an exercise. They look forward to the time when they will be able to take part as performers, and the idea that science is a very interesting subject is strengthened.

JELLYFISH ARE DEADLY ENEMIES OF SMALL MARINE FISHES

Jellyfish, though the popular synonym for flabby spinelessness, are by no means harmless. They capture and devour baby fishes of all kinds in great numbers, says Dr. E. W. Gudger of the American Museum of Natural History, in the Bulletin of the New York Zoological Society. One specimen was kept under observation in an aquarium, and in six weeks ate a couple of dozen tiny fish.

Other species can capture and devour fish much larger than themselves. One, which Dr. Gudger describes, pulled itself over its catch like a mitten over a hand. Another, in its eagerness to get its stomach around its victim, literally turned itself inside out.

The jellyfish itself is not a real fish, but belongs to a much lower order of life. It consists of an umbrella-shaped body, with a fringe of long tentacles armed with paralyzing stings for capturing its prey, and a projecting mouth-like organ in the middle.

Not all fish are ready victims to jellyfish. There is at least one species that can dodge in and out among the deadly tentacles, and seems to prefer thus living paradoxically in the protecting shadow of a known and familiar danger to being exposed to the attack of other fish that fear its stinging, hungry host. Yet the jellyfish's little housemate is not immune to the stings, as has sometimes been stated. Dr. Gudger cites observed cases where individuals of this species, touched by the tentacles, have been paralyzed, drawn up to the mouth, and engulfed.—*Science Service.*

"WHAT'S WRONG" TESTING OF LABORATORY TECHNIC

By Ralph E. Dunbar and Robert Cooper
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Diwoky and Lewis (1) report the use of drawings for stimulating interest in laboratory technic. Their drawings included glaring mistakes that had been made by students working in the laboratory, as well as other less obvious mistakes. These drawings were then posted on the general chemistry bulletin board for student observation and study. The authors report that better laboratory technic has been stimulated by these drawings. Condon (2) has prepared a series of "What Is Wrong?" drawings which was used as the basis for a contest for high school and freshman students. We have prepared a similar set of drawings and have used them for testing laboratory technic in inorganic chemistry classes. The tests in each case have been administered after the students have completed the corresponding experiments in the laboratory. They can be used as a test of the information gained and retained, as well as proper laboratory technic of the student. Mimeographed copies of each drawing were given to each student during a regular class or test period. Blank lines were provided and the students instructed to list all mistakes in either the arrangement of equipment or chemicals used. They were likewise advised to indicate the proper procedure where any mistake was present in the drawing. A perfect score would necessarily include a complete tabulation of all of both items. Other replies could be proportionately graded.

Our experience in using these tests has indicated that there is a relatively high correlation between the scores on these tests and the actual laboratory technic of students, as evidenced by their work in the laboratory. We have also found that beginning students generally score higher on items involving equipment than chemicals.

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1. Diwoky, Fred F., and Lewis, John R. "The Use of Drawings for Stimulating Interest in Laboratory Technic," Journal of Chemical Education, VI, pp. 1523–1524, September, 1929.
2. Condon, John J. "A Contest for High School and Freshman Students," Journal of Chemical Education, VI, pp. 1785–1786, 2020–2021, 2262–2265, October, November, December (1929); VII, pp. 167–170, 436–440, 661–665, 893–896, 1166–1168, 1402–1403, January, February, March, April, May, June (1930).

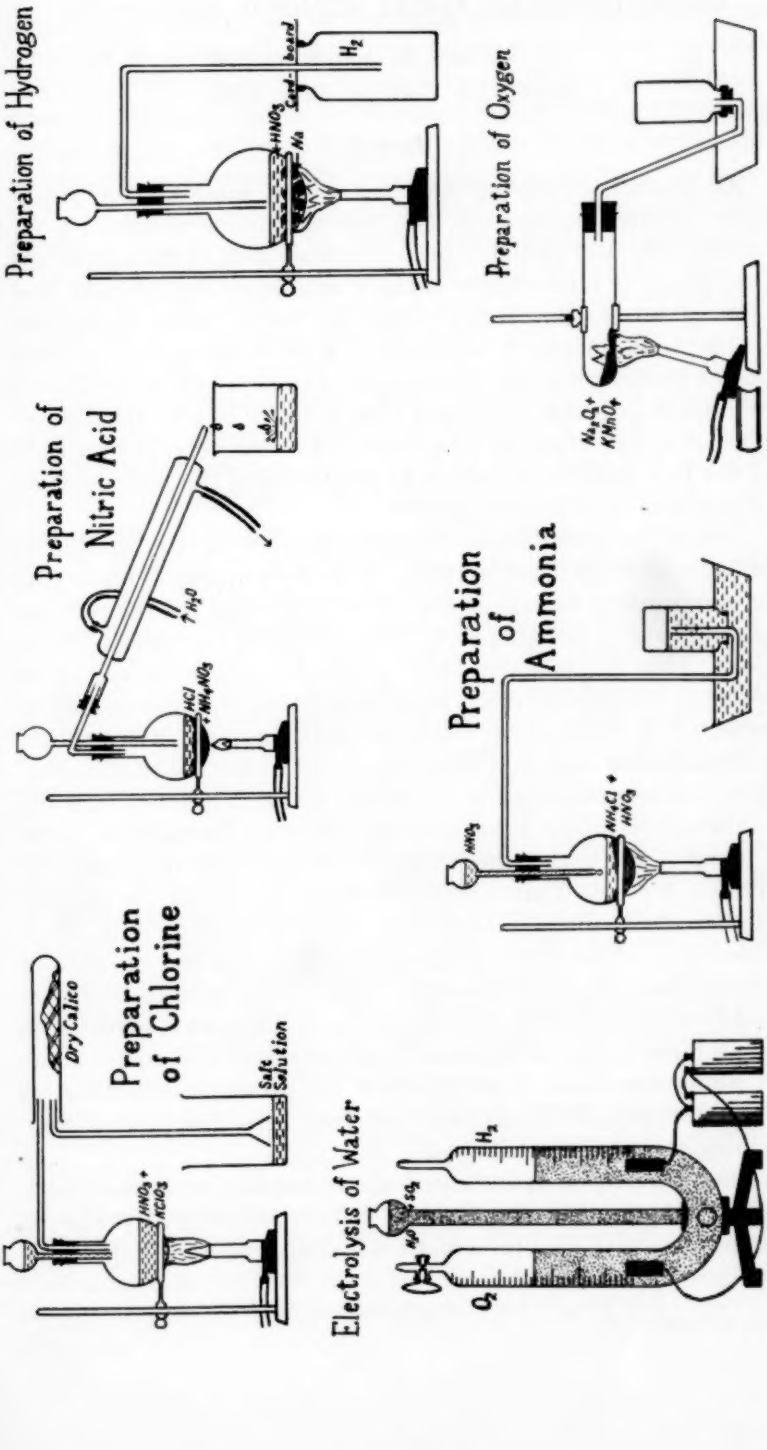

Fig. 1. Representative "What's Wrong?" Drawings.

OBJECTIVES IN HIGH SCHOOL BIOLOGY*

By Harry A. Cunningham
Kent State College, Kent, Ohio

Part I

All teachers of biology have, of course, some kind of objectives. There are, however, two points of view concerning objectives that had probably better be dealt with at the beginning. One group is interested in science as subject matter only and often maintains that it really does not matter what the subject matter is so long as it is science. These people point out that no one knows when the facts taught may be found to be of vital individual or social value and that it really is a better demonstration of the scientific procedure and of the detached attitude of the true scientist to ignore in our teaching the consideration of practical or utilitarian values.

The other group takes the point of view that education in biology, as in all other subjects, is for the purpose of modifying or conditioning behavior; that it is to be used for the purpose of producing or bringing about better types of reactions to situations. This group states that objectives should be set up in terms of the modifications in behavior that may reasonably be expected to result from teaching; that these outcomes should be measurable; and that teaching should be for the specific purpose of accomplishing the objectives set up. The writer belongs to the second group. What activities are most desirable for man?

Briefly, and rather dogmatically, we may say that those activities are best that contribute most to life at its highest. Higher life is distinguished from lower insofar as it is better able (1) to adjust itself to changes in its environment; (2) to be independent of its environment; and (3) to have control over and be able to modify and change its environment. Civilization as we know it has as its essence specialization and cooperation. It would seem that, if we interpret the present social situation aright, some individuals have not been behaving so as to contribute most to life at its best.

Such activity as is indicated above implies, of course, intelligent behavior. That individual behaves intelligently who, in connection with his problematic situations, tries out rapidly by

* Presented at the Biology Section of the Northeastern Ohio Teacher's Association on October 27, 1934, in Cleveland, Ohio.

means of language each of the many possible reactions to the situation and then selects the one for overt or actual trial that has been successful in the language try out. The degree of intelligence is proportional to the degree of high correlation between success in the vicarious, language, try-out and success in the overt, or actual, try-out. It is the purpose of biology education to do its part in furnishing the necessary language equipment to enable individuals to try out the many possible reactions to a situation vicariously, by language, and to enable them to reach a high degree of correlation between success in the language try-out and success in the actual try-out. It is also the function of biology education to do its part in making skill in this method of problem solving, the scientific method, an object of desire and, finally, in making it habitual. Biology, together with the other sciences, is particularly suited for this purpose since the most amazing thing that has occurred during the last hundred and fifty years has been the remarkable advance in science. This amazing advance has been due entirely to the effective use of the scientific method.

Now it is pretty generally agreed that many of those of the present generation who have assumed the responsibility of leadership have failed to react intelligently in many social situations. This questionable behavior on the part of so many of present day citizens, who have essayed to be leaders and whom our schools have trained, has resulted in criticism of our schools. This is as it should be because the specialized school was set up by society to provide training at those points where it could no longer be provided efficiently by the home or by the neighbors. In the present critical situation the school should be both willing and able to provide intelligent answers to the criticisms made. To this problematic situation the schools, insofar as the writer knows, have been either unwilling or unable to react intelligently. The following quotation reflects the point of view taken by many educators.

> If the political and economic leaders had followed the teachings of the schools, we should not be in our present difficulties. The schools never taught war, they taught peace; the schools never taught disregard for law, they taught respect for law; the schools never taught national isolation and selfishness, they taught international participation and cooperation; the schools never taught extravagance, they taught thrift.[1]

If society cannot hold the schools responsible to a very great

[1] Coffman, Lotus D., "Youth Forced to Pay the Bill," School Science and Mathematics, Vol. 32, No. 6, June, 1933.

extent for the behavior of her citizens, where can the responsibility be centered? We, as teachers of biology—a subject, the teaching of which provides so many opportunities for furnishing the necessary language equipment for the solution of many of our problematic situations, both individual and social, should take our share of the blame for our present unpleasant social predicament and should likewise accept our responsibility in this matter in the future with increasing seriousness. For the schools to merely say that they taught the present generation one thing and that the present generation is now doing the very opposite is too easy a way to side-step responsibility. Educators are quick to take the credit for those of their product that turn out well but do not take the responsibility, so readily, for those who turn out badly. Should the school not take equal credit in each case? The writer is fully aware that there are many problems involved here, that cannot be more than mentioned in this paper, and that our point of view toward them depends, somewhat, upon our interpretation of scientific data.

Two of the ideas that have been quite generally held by educators, on the basis of which they find grounds for evading their responsibility as to the behavior of their product, are Original Nature and Free Will. It has been very commonly thought that certain characteristics of the individual are innate in that they are due entirely to heredity. Biology teaches that, in this sense, nothing is innate; that the physical characteristics which are present at any time in the life of an individual are the result of what the inherited materials or factors have been able to make in response to the environmental factors that have prevailed; that the inherited factors are the workmen but that the environmental factors are the architects. In speaking of environment we refer to both external and internal environment.

On the basis of Free Will, educators again evade their responsibility. They seem to assume that there is some mystical force aside from either heredity or environment that enables an individual to direct his own course. Biology teaches that the structure of the entire body of a living organism is being continually modified or changed by the hereditary factors as a result of bodily activity; that the bodily activity of an organism at any instant is due to the structure of the organism at that instant on the one hand and the environmental factors that are stimulating the structure on the other but that all activity, and

therefore all change in structure comes as a response to stimuli. This means that, within the limits set by heredity, environmental factors (education) are deterministic.

Let us lay aside our fatalistic attitude concerning the possibility of educating most individuals of normal structure and accept our responsibility for so changing the structure of individuals that they will react in an intelligent manner toward the most important problems of life. We have no more impressive examples of the possibilities of modifying behavior through environment than that of Helen Keller and that of those cretins who, with one outfit of hereditary factors but with a defective internal environment due to a lack of thyroxin are defectives in structure and behavior, and who, with the very same hereditary outfit but with a changed internal environment due to the introduction of thyroxin, are normal in both structure and behavior.

In our consideration of objectives of high school biology we must realize at the outset that there are objectives on various planes of generality; some very large and general and others smaller and more specific. The smaller and more specific objectives are of use in the attainment of the larger and more general ones. It follows, therefore, that all the objectives that are generally included in lists of objectives cannot be comparable in the sense that they can be ranked as to importance. One of the most futile things that I ever attempted has been the ranking of lists of objectives including in the same list *life activities, scientific method, science principles, science information, ideals, etc.* These are all necessary objectives at various levels but some cannot be ranked above others. Various life activities can be ranked according to criteria. Various ways of carrying out the *scientific method* can be ranked. It is impossible, however, to rank *life activities* and the *scientific method* one above the other. In the latter case one, the *scientific method* is necessary for the accomplishment of the other. For the same reason it is impossible to rank science principles and specific science facts. The facts are necessary for the development of the principles.

It is important, I think, that teachers see the entire sequence of objectives from the top to the bottom in their proper relationship. In other words, they must be general educationists on the one hand and biology specialists on the other. They should be good in both. The assumption is too often made that if you happen to be fairly good in one field that you are, of

course, superficial in the other. This combination should be especially interesting to the biologist because the very foundations for the understanding of behavior are found in his own subject of biology. More educators should study this material.

This is probably too much to ask of the biology teacher when we remember that no committee of experts in science education has thus far been able to do more than select one type of objective and emphasize it to the exclusion of most other objectives. In 1920 a committee of science experts produced a Bulletin entitled, "Reorganization of Science in Secondary Schools",[2] in which the emphasis was placed primarily upon Life Activities such as Worthy Home Membership, Citizenship Activities, etc. In 1926 we had another committee of experts writing upon elementary science in the Fourth Year Book[3] of the Department of Superintendence of the National Educational Association in which emphasis is placed upon smaller activities such as feeding squirrels, watching frogs out of doors, bringing pigeons to school, etc. In 1932 still another committee of experts in Science Education produced the Thirty-first Yearbook, Part I, for the National Society for the Study of Education.[4] This time large science themes were emphasized to the disadvantage of other objectives. These science themes were such as: "Through interdependence of species and the struggle for existence a balance tends to be maintained among the many forms of life"; "All life comes from life and produces its own kind of living organism," etc. Thus you can see how very difficult it is even for those who are supposed to be expert to visualize at one time the complete picture. If it is so difficult for experts to do this, those of us who are ordinary teachers may probably be pardoned if we find it difficult also.

It is well, I think, to remind ourselves that the objectives at all the various levels indicated are really activities either vicarious or overt. To the actual overt activities of life we have of course applied the name, life activity. To the many activities, both vicarious and overt, that are carried on in developing the ability to experience by language activity the relationships between certain natural phenomena, called causes, which precede

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[2] Caldwell, O. W., and Committee, "Reorganization of Sciences in Secondary Schools," United States Bureau of Education, Bulletin 1920, No. 26.

[3] The Department of Superintendence. "The Nation at Work on the Public School Curriculum," Fourth Yearbook, National Education Association, Washington, D.C.

[4] National Society for the Study of Education, "A Program for Teaching Science," Thirty-first Yearbook, Part I, Public School Publishing Company, Bloomington, Illinois.

certain other activities in nature that are termed effects, we have attached the symbol generalization. To the activity of classifying various objects that we have grouped together by giving them a common name or term we give the name concept. To the activity of first labeling various single objects in nature and single overt activities by means of words we often give the name science information. To the various activities either vicarious or actual that are performed in the biology classroom we generally give the name classroom activities. Now there are different ways of performing these activities at all of the various levels. In order to further our ability to deal with the details of an activity vicariously we attach words, called adverbs, to each of the various ways of performing the activities. The types of activities for which the various adverbs stand are all grouped together and labeled with a single term. This single term is sometimes traits and sometimes characteristics. Whenever anyone of these traits, or ways of performing activities, becomes an object of desire we say we have set up an ideal. The term ideal, then, is the word assigned to traits that have been made objects of desire. We are concerned, therefore, with traits and ideals in connection with the activities at all various levels, to the degree to which we are concerned about the manner in which the activities of life should be performed. The scientific method, as the best way or manner to solve all problems, should be set up by biology teachers as an ideal of first magnitude. Proper performance of the various activities of life is, we may say, the largest and ultimate objective of biology teaching and of education in general.

We have already seen that living organisms respond only to environmental stimuli. Many environmental stimuli are operating upon an organism at any one time. To groups of these environmental stimuli we assign the term situation. These situations with which we deal are very complex. It is, of course, beyond the power of biology to deal with all the factors in such complex situations. But in the reaction to many of these complex situations, one or a very few of the factors involved may seem to be dominant. In a very great majority of life situations some of the most important factors in them are biological in nature. It is the business of the biology teacher to present these situations, to point out the spot at which biology plays an important part in meeting them intelligently and then proceed to give the biology which applies.

A SINGLE-PERIOD LABORATORY, A DEMONSTRATED SUCCESS

By H. Clyde Krenerick
North Division High School, Milwaukee, Wisconsin

About twenty years ago, I was somewhat surprised and grieved when told by the Principal that there would be no more double laboratory periods. The order was definite and so I began at once to rewrite my laboratory instructions for the single period. Before the year was over I was very grateful for the compulsory change. I have never desired to change back. I much prefer the single period. I would hate very much to be compelled to use double periods.

Such an attitude, I know, is very radical to many and will need considerable explaining. The acceptance or rejection of my explanation will depend, largely, on the method, the object, or the importance that *you* give to *your* laboratory work. My own method of teaching physics is to have the laboratory the most important part. Practically the entire course or discussion is built around the experiments, previously performed by the students in the laboratory.

Our laboratory at North Division is equipped for twenty-eight students. In a large majority of the experiments we have twenty-eight duplicate sets of apparatus so that all students work individually and on the same experiment. The students during the year perform ninety or more experiments. The only reason that we do not perform more is not because of lack of time, but because of a lack of experimental subject matter. The ninety experiments introduce practically all of the principles and subject matter of elementary physics.

The students are given an assignment and the next day they go directly to the laboratory and perform the experiment without previous classroom discussion. When the laboratory work precedes the classroom discussion, it is absolutely necessary that there be perfect correlation. Such correlation is not possible when laboratory days or double periods come on each Tuesday or Thursday or on certain definite days. The subject matter of the text that is adapted to laboratory experimenting is not so periodically arranged.

When double periods are given each day for laboratory courses, correlation is, of course, possible. But with a double period you have no right to ask for outside preparation. Exten-

sive home work is now getting critical consideration. With double periods you have exhausted your portion of the students' time. You should then resort to some form of supervised study of which I am not in favor. I am still old-fashioned enough to believe that the main objective of education is mental discipline, which, I believe, can be developed best by individual accomplishment of some definite task.

The greatest objection to the single period would be the lack of time. In chemistry it may be difficult sometimes to set up the apparatus and perform the experiment in a period of forty-five minutes. But it is not difficult in physics. Not only do our students work the experiment; they must get their apparatus and put it away. They must complete their records and have them accepted by the end of the period. An optional or extra part is given with each experiment for the better or faster working student. A majority of the students also do the optional part.

To accomplish all this in so short a period of time, there can be no waste of time. You could perform any experiment of the laboratory in a few minutes, because you know exactly what is to be done and how you are to do it, and so the time required by the student will depend on how definitely he knows what is to be done and how he is to do it. Consequently the success of the single period depends, largely, on the nature of the instructions and on the student's preparation.

The instructions must be simple, clear and positive. Our instructions were rewritten and rewritten until each statement was found to be intelligible to the high school student. Many of our experiments, when being designed, were performed dozens of times by myself and other instructors, varying the details of method and apparatus used, before they were tried out on the students. After trial it was often necessary to again remodel. It took considerable time and work, but the results are now very gratifying.

I have never been satisfied with experiments designed and written by college professors for high school students, especially when the professors have not taught high school physics for the past twenty-five or thirty years. Such manuals are often written to sell rather than to use. In the effort to make them adaptable to all schools and all equipments, they are so general, so lacking in detail, that they are difficult for the high school student to comprehend.

Our ninety experiments have not been abbreviated because of the short periods. They are rather more extensive than the average laboratory manual experiment. In our experiment on specific gravity, for illustration, we determine the specific gravity of a heavy object, of a floating object, of a liquid by the sinker and by the specific gravity bottle methods. Four determinations in one experiment. Each experiment is substantial, quantitative and designed for the same period of time, forty-five minutes.

To *compel* the students to make previous preparation, we use the following system: The instruction given in our manual is not a complete discussion of the related subject matter, but is written on the assumption that the student is familiar with the correlated subject matter in some text. They are not allowed to bring their text books to the laboratory and they are not allowed to communicate. Consequently they soon discover that if they do not make preparation, they are hopelessly lost in the laboratory and that it soon becomes very evident to all and especially to the instructor.

The preparation is of a far more intensive nature if the student knows that he is to think and perform by himself instead of observe a teacher demonstration and take part in a mass discussion. Bluffing is a fine art to many of our high school students but in individual laboratory, so planned, the art is of no avail. Each day's work is a sort of test, and test days are given a little more serious consideration.

I used to mimeograph the instructions and give a copy to each student as he entered the laboratory, but for the past four years each student has his privately owned manual and I have been very much surprised at the more thorough preparation and the greater ease with which they perform the experiment.

I am thoroughly convinced that far greater results are obtained when the students have the instructions, or a manual, in their possession for previous preparation. They then come to the laboratory with a definite idea of what they are to do and how they are to do it. Their curiosity has been aroused, they are interested and eager to see how it is going to work out. It is original research to them, if their interest in the project has not been dimmed by having seen it previously performed on the lecture table. To me, these are strong arguments for the method of having the laboratory precede the classroom discussion.

One other way in which our manual has helped, greatly, to make the single period a success, is that it contains a photograph of the set-up. Not only does the photograph save time in setting up the apparatus, but it helps in the interpretation of the instructions. However good and complete the diagram, it does not take the place of the actual photograph with the amateur mind.

To be able to check the results or records of a class of twenty-eight students in the closing minutes of a period, the form of record must be simple. There are three parts to our record: the tabulation of data; the indicated steps of computation; and the statement of certain conclusions. All this is completed in the laboratory. No time is spent on an elaborate write-up of the experiment outside of the laboratory. The primary task of the physics teacher is to teach physics, and so we leave the composition and the narration to the English department and the drawing to the art department. We prefer that the student spend his home-study time for preparation of the next day's experiment or classroom discussion. Each experiment has a definite form of tabulation so that all records are uniform and easily checked in a few closing minutes of the period.

It must be evident that at North Division Milwaukee, we are not much in sympathy with those that advocate the teacher demonstration method. We are rather of the other extreme, introducing practically the entire subject matter of the year's work by individual student laboratory experimenting, believing that a student can better acquire mental development or scientific thinking by his own mental efforts than by observing the game from the side lines.

If teacher demonstration is just as effective, why do not our educational experts advocate it for the teaching of mathematics and many other subjects? A teacher can demonstrate very clearly and very satisfactorily to a class how to extract the cube root of a number, then why ask the class to do individual work on the subject?

We are told that "education for leisure demands a new type of science education." Does it demand that we go back to the ox-cart days of teaching physics without a laboratory, or does it demand greater laboratory facilities, greater opportunity for the individual to develop his initiative and his constructive abilities? Which will the better develop interests for leisure time?

No other academic subject in high school offers as good op-

portunities for learning by doing as physics. I am convinced that "learning by doing," when possible, is the best method of learning. So many of our students for some mysterious reason, fail to connect the things they learn in classes to life situations.

In our experiment on the construction and use of the vernier caliper, we have them measure the diameter and circumference of a cylinder and then, for a check on the accuracy of their measurements, divide the circumference by the diameter. Over sixty percent of them do not know, when asked, what that quotient should be. Yet the majority of them were good students in mathematics. They had used the ratio many times but failed to recognize it when they came in contact with it in reality. This to me is sufficient proof of the superiority of the laboratory method of teaching physics, or any other subject where the method is applicable.

To me, another very conclusive evidence of the superiority of the laboratory method is that we cover the subject matter of the text more completely and more thoroughly. This past year, I added twenty more experiments to our list and it was my first experience of covering the entire subject matter of the text in plenty of time for a review at the end of the semester. I am using the same set of questions, completion type, that I used some years ago, and with about half as much time spent in class drill as formerly, the grades have very decidedly increased.

Last semester we covered heat, excluding the gasoline engine, in four and a half weeks, performing thirteen experiments. Five years ago we performed five experiments in heat and spent nearly six weeks on the subject. At the end the same sets of test questions were used. The average grade of all the sections five years ago was sixty-one. Last semester, it was seventy-two.

Other physics instructors have told us that we accomplish more in our single period than they do in a double period. That may sound strange, but it is more strange to say that it is reasonable to expect that we should. With our instructions the student must know when he comes to the laboratory what he is going to do. He has no time to merely follow the instructions. With the usual manual and double periods, he does not need to make preparation. All he needs to know is in the manual. All he needs to do is to mechanically follow the instructions. When he is ready to compute results the manual shows him just how to do it. The necessary conclusions are also suggested in the

discussion preceding the instructions. This may all be accomplished while thinking of the coming social event.

The matter of expense has been to some an argument in favor of teacher demonstration. The large majority of our ninety experiments are in duplicate sets of twenty-eight each, yet I have not had any more money to spend than the other high school physics teachers of the city, some of which are performing only twenty-eight or thirty-two experiments in the year's work. They have spent for demonstration pieces which are more expensive. The initial cost of equipping a laboratory may seem large, but when the large number of classes per day and the many years that the apparatus will last is considered, the expense per pupil is matter of only a few cents.

We are told that the teaching of physics is becoming "sterile," that the text books of today differ but little from the text books of thirty years ago, that there are no "general trends" revealed in recent surveys. I hope the information is correct, that the teacher demonstration method has not reached the magnitude of a trend.

Those of us who have grown grey in the profession have witnessed many new movements, or reforms in teaching methods, that have sprung up with a mushroom growth and then suddenly died an unnatural death. When they are substitutes for real honest-to-goodness work, they do not seem to survive long.

The latest departure is the so called laboratory exercise or work book, a sort of cross-word puzzle proposition. A completion type set of questions to be filled out by the student with the text book at hand. A few weeks ago, I received a copy for inspection from a publishing house with a statement inclosed that it had been adopted by three thousand schools during the past year. That sounds like the beginning of a trend.

With the purpose of the exercises, as stated by the author, there can be no argument; but will they be used as intended, and are the advantages derived from the exercises in proportion to the extra time required of the student and of the teacher? I would expect the students to copy from each other. I would expect them to copy without so much as reading the question. The market value of second hand books would soon be above par. I feel no written task should be assigned to a student that is not later checked. If he is conscientious in his effort, he is entitled to know the accuracy of his work.

The promoters of each new method have claimed the proof

of the efficiency of their system by various tests. But do such tests test other than the memory, the facts retained? Were you ever embarrassed by having as tudent come back after an enforced absence and write a better test than the average of the class or better than he usually wrote when present for your instructions? If you are consistent, what does this prove for your teaching methods?

We give tests but they are given only for the purpose of testing the student's factual knowledge. To test the student's skill, achievement, or real knowledge of the laws and their applications, where can you find a better test than a laboratory test? With our system of previous preparation and individual laboratory work, each assignment is a problem and each laboratory exercise is a test on the student's knowledge and solution of that problem. The students know that they are graded each day.

I used to think, with many others, that physics was too difficult a subject for students to prepare with their own efforts, and consequently presented it by demonstration and class discussion. A short time ago a former student told me how he enjoyed physics. He said that I made things so clear that he never had to spend more than ten minutes on the subject. I suppose that he was paying me a compliment, but to me it was a severe criticism of my methods. I was glad that I could tell him that I was no longer teaching physics that way, that the students were now doing the work and that I had the ten minute end of the job.

The content of the physics text is not too difficult for the large majority of our high school seniors, when they make an honest effort. They are perfectly willing that you should consider the subject difficult and do the work for them. When we come to a difficult experiment we tell them that it is difficult and that it is going to be a test of their ability. They seem to like the challenge and go for it strong.

When students without any previous demonstration or discussion of accelerated motion, can, through their own study, go to the laboratory, roll the ball down the grooved plank, measure the distances, compute the velocity at the end of each period, determine the acceleration during each period and finally discover in their data the proof of the formulas or laws of uniformily accelerated motion, they have demonstrated that the subject matter of physics is not too difficult. I, also, maintain that in

such an accomplishment, they have acquired a mental development or a scientific ability to reason that could not be acquired by any teacher demonstration.

We often hear the general criticism that our students no longer think. I wonder if we have to go far from home to find the cause. I wonder if it is not the natural result of our various devices for easy, quick, effortless imparting of knowledge, such as pictures, animated films, teacher demonstrations, mass discussions, supervised study, socialized recitations, etc. We are told that a lack of solid food has produced a soft gummed generation. I wonder if we have a parallel in the teaching profession.

To summarize briefly, I prefer single periods for laboratory work because it makes possible at all times, perfect correlation between the laboratory work and the classroom discussion, which is absolutely necessary if the laboratory work is to precede the classroom discussion.

I am opposed to double periods for then the legitimate portion of the student's time to be devoted to one subject has been exhausted and no task should be assigned to him for outside consideration or accomplishment.

A substantial, quantitative experiment can be performed satisfactorily in a period of forty-five or fifty minutes if certain plans or methods of laboratory procedure are employed. To make the results most successful, I would recommend the following conditions:

That the experiment be designed and written for the shorter period. Instructions positive in meaning and apparatus simple.

That the laboratory work precede the classroom discussion so that the students will have a keen interest in the experiment.

That a copy of the instructions, or a manual, be had by the students before the time of the experiment so that the students may make preparation.

That the nature of the instruction, or manual, be such that the student must make preparation.

That the students work individually on the large majority of the experiments. The habit will then be formed and they will be independent when working with others on the same apparatus.

That a sufficient number of duplicates of the apparatus be had that the entire class may work on the same experiment.

That a uniform system of tabulation be used so that the instructor will be able to check all records in a few minutes at the close of the period.

That the student's record be simplified to three requirements: data, computations and conclusions.

That the laboratory work be made the nucleus of the entire course, introducing all principles, laws, or subject matter, whenever possible, by student laboratory experiments.

A NOTE ON THE REPRESENTATION AND EVALUATION OF POWERS OF *i*, WHERE $i=\sqrt{-1}$

By G. D. Gore
Central Y.M.C.A. College, Chicago, Illinois

The following comments are to the point of a recent paper in this journal, by L. R. Posey.*

The Author has recommended School Science and Mathematics to his college students, and has put copies of it into their library. He therefore feels that it is desirable to have the mathematical principles and subject matter advanced in that journal at least up to a level of dignity and soundness of principle which is appropriate to classroom instruction.

A teacher may choose the less simple of two otherwise optional methods of presenting a fact in order to lead a student along a line of thinking which does not block the major principles of the subject under consideration. But he is rarely justified in leading a student up a blind alley, only to evaluate some fragmentary result. It is a characteristic of beauty in mathematics that the simpler representation of a principle often leads to a path of thought which has the greater vistas. However, this is not always the case. Kepler's discovery of his famous three laws of planetary motion was delayed many years because he insisted that Nature would use circles, the simplest and most perfect of curves, instead of ellipses as planetary orbits.

Coming now to the matter of evaluating powers of i where $i=\sqrt{-1}$, the author does not concede any reason why this should be a problem of difficulty, either from a mathematical or a pedagogical point of view. To those who have encountered difficulty with the problem, he submits the following simple,

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* Posey, L. R. "A Method of Determining the Sign and Value of i^n, Where $i=\sqrt{-1}$, and n is Any Rational Positive Integer, Equal to or Greater Than Two." School Science and Mathematics, November, 1934, Vol. 34, pp. 812–815. (All integers are in the class of rational numbers.)

and rather conventional procedure which is guaranteed to be teachable, effective, and pedagogically harmless. The result is not a set of rules, but a self motivated logical procedure.

The student can easily prove by straight multiplication, in case he can not remember, that if

$$i=\sqrt{-1},$$

then

$$\begin{aligned} &i^2=-1, \\ (1) \qquad &i^3=-i, \\ &i^4=1. \end{aligned}$$

A student who can not master this feat will never find his star in mathematics, nor will he ever know enough about i to use and appreciate it. But granted the definition of i and the paradigm (1), it will be shown that all higher integral powers of i can be evaluated by them.

The last of equations (1) states that fourth powers of i may be replaced by unity. As a consequence, multiples of four may be dropped from the exponent n of any power i^n. Hence we have a fundamental reduction formula

$$(2) \qquad i^{4m+r}=i^r,$$

where m is any integer, and r can be made positive and less than 4. The following examples make clear the application of formula (2):

$$\begin{aligned} &\text{(a)} \qquad i^{753}=i^{(4)(188)+1}=i, \\ &\text{(b)} \qquad i^{22}=i^{(4)(5)+2}=i^2=-1, \\ &\text{(c)} \qquad i^{27}=i^{(6)(4)+3}=i^3=-i, \\ &\text{(d)} \qquad i^{467152}=i^{(116788)(4)}=i^0=1. \end{aligned}$$

Examples (a) and (d), above, should be shortened. Since any integral multiple of 100 is divisible by 4, if we delete all of the digits except the last two in a given integer, we merely reduce the integer by an integral multiple of 4. Utilizing this fact.

$$i^{467852}=i^{52}=i^0=1.$$

To elucidate the above properties of i, even if the students have not had trigonometry, we can make use of a system of rectangular coordinates with a unit circle about the origin as center. Place the numbers $1, i, -1, -i$ at the points of the unit circle whose coordinates are $(1, 0)$, $(0, 1)$, $(-1, 0)$, $(0, -1)$ respectively. Observe that when one of the above numbers is multiplied by i, the product is the value which is one quadrant ahead on the unit circle. Hence if any one of these numbers be

multiplied successively four time by i, its value will traverse one complete circuit, and it will ultimately be unchanged.

The use of the coordinate plane and of the unit circle to depict the above relations is recommended because it gives a natural approach to further development of the subject. It is this type of representation which was used by Kühn, Argand, and Gauss in their efforts to establish i as a legitimate and logical member of our number system. It is through such a coordinate representation that one is able to demonstrate the vector properties of complex numbers, the properties which have been found so useful in the study of dynamics. By applying trigonometry to the coordinate representation of complex numbers, one is able to establish the Theorem of De Moivre, which suggests at once a method for finding all of the n-th roots of any number. The latter problem is fundamental to the theory of algebra and to nearly all of higher mathematics.

FINDS BODY TISSUES ARE NOT GERM-FREE

Within a few minutes after birth, the blood and every normal tissue of the body are constantly invaded by the ordinary bacteria or "germs" found on the skin and in the mouth and nose, Dr. Lars F. Gulbrandsen of the University of Illinois College of Medicine has found.

This discovery upsets the prevailing idea that the blood and tissues of the body are as a rule sterile, that is, free from "germs" or micro-organisms. Dr. Gulbrandsen finds the "germs" present in a changed form and believes that this change constitutes one of the body's major means of defense against disease.

So far there has not been time for other scientists to confirm Dr. Gulbrandsen's findings and theories, but his study is said to open a new field in the investigation of disease and resistance.

The bacteria or "germs" come to the tissues through the wall of the intestinal tract from food that has been taken through the mouth, Dr. Gulbrandsen believes.

New-born guinea pigs, he found, did not have bacteria in their body tissues at birth. But within fifteen minutes after feeding them pure cultures of bacteria by mouth, the micro-organisms could be found in the animals' tissues.

The bacteria, however, had undergone decided changes of a type known to bacteriologists as dissociation changes. They had no power to produce disease in the healthy individual and would not grow under ordinary cultural conditions.

It is this dissociation change which Dr. Gulbrandsen believes constitutes one of the body's major mechanisms of defense against disease.

Further work is being done to learn whether the bacteria pass through the lining walls of the intestinal tract intact or whether they are changed in that passage and can then return to their original form in the body tissues.

For this research Dr. Gulbrandsen was recently awarded the $500 Capps prize of the Institute of Medicine. This prize is given each year for the most meritorious medical research by a graduate of a medical school in Chicago completed within two years after graduation.—*Science Service.*

THE BOB-WHITE QUAIL: A UNIT OF WORK IN CONSERVATION

By William G. Vinal
Western Reserve University, Cleveland, Ohio

The greatest danger to the bob-white in Ohio lies in the proposal to return it to the game bird list. The Cleveland Bird Club believes that this is an opportune time to conduct an active educational campaign about the bob-white. Believing that scientific procedure is essential here as always, the Club is going to adhere to the principle that students find out the facts for themselves. It wants them to use the very best means at their disposal to discover the truth even though it does not agree with their sentiment. This will mean the study of authoritative literature and the interviewing of reliable people who have information to offer. To this end, a suggested list of problems is presented.

In order to further stimulate interest the club is offering \$10.00 for first prize, \$5.00 for second prize, and \$3.00 for third prize for the best paper submitted by any class in the grades, intermediate or Junior High. All papers should be composed as a class project, typed in double space on 8.5×11″ paper, and submitted with name of city, school, teacher, and grade on a separate, but accompanying card. These should be sent to the President of the Cleveland Bird Club, Western Reserve University, Cleveland, Ohio, before June 1, 1935. The papers will be submitted to a competent committee of judges. Publication rights will rest with the Cleveland Bird Club with due credit.

I. The Situation: In Ohio the bob-white has been protected by law since 1915. Year after year the Ohio Legislature is confronted with a bill which aims to return the quail to the game bird list. In 1935 seven bills were designed to make the bob-white a game bird. The perennial appearance of these bills suggests that there is not only a need for the clarification of the facts, but for a widespread education campaign on the part of Conservationists. Now is the time to act before there is a run on the "First National Bank of Bob-Whites."

II. Objectives

General: To become conservation-minded.

Specific:

To know that bob-whites are valuable because they eat weed seeds and injurious insects.

To realize that bob-whites are valuable because of the pleasure they give us.

To know that bob-whites are prized song birds in Ohio, to be enjoyed, but not to possess, dead or alive.

To know that the bob-whites are a social heritage rather than an individual heritage.

To recognize when wrong and foolish statements are made about the bob-white.

To gain in the ability to judge facts and weigh evidence.

To know that those who would save the bob-white far exceed in number those who would shoot the bob-white.

To co-operate in protecting the bob-white for the good of the greatest number of people.

To know that the bob-white in Ohio are not of sufficient abundance to withstand a large killing off through hunting.

To realize the value of scientific procedure in caring for the bob-white.

To know that in the past man has exterminated wild birds by mismanagement.

III. Things to do: Individuals or committees of the class may contract to carry on the following investigations, i.e., if there are forty-eight in the class, there can be sixteen committees with three on a committee. Each committee should report the findings to the class for discussion and criticism. The report is then rewritten for the final paper.

(1) *The Bob-White and Weed Seeds:* How do scientists determine, beyond the possibility of a doubt, just what food is eaten by a bird? Do bob-whites eat weed seeds? If you have acceptable evidence that they eat weed seeds, give data as to how many weed seeds they eat. Do they eat grains? Are bob-whites injurious on a grain farm? Have authority and reference for every statement that you make. These should be written in the same fashion as the bibliography at the end of this article. Guess work, opinion, and hearsay are not acceptable.

(2) *The Bob-White and the Drought:* Where can one go to get exact data as to whether Ohio has had "drought summers"? Present the evidence in such a way that there can be no doubt about your conclusions. What years have been drought years?

What has been the effect on the corn crop? What has been the effect on the amount of weed seeds? How would drought years effect the bob-white? How would grass-land fires effect the bob-white? What is your authority in each case?

(3) *The Bob-White and Winter:* Every Ohio winter is an emergency situation for bob-whites. Bob-whites in Ohio are at their northern outpost. That means that they are in a "danger" zone where they can just hold their own against the cold and the snow. Bob-whites sleep in a circle with tails pointing in and beaks pointing out. Of what advantage is this? When there is deep snow they sometimes huddle under the deep snow. If it rains and then freezes the covey is entombed by a crust of snow. Unless released by friends, they may starve to death. When the snow covers the food supply these ground birds are in a precarious situation. If this adverse condition continues, they starve. Make a list of acquaintances who feed bob-whites. What do they feed them? How much do individual birds eat? How many weeds might bob-whites prevent? Perhaps you can be a guest at the feeding. Find out whether this paragraph is just sentimental thoughts of a bird lover, or whether it presents a true picture. The name, address, and attitude of each person interviewed should be noted. Write your findings.

(4) *Bob-Whites and Farmers:* Would it pay in dollars and cents for a farmer to leave a few rows of corn standing in the fields in the fall? How can one get a scientific answer? What would be your opinion about a farmer raising quail and allowing sportsmen to shoot them paying a fee for the privilege? Might this solve the problem of quail management? Assemble all the reliable data that you can and present your conclusion. Exact references should be used.

(5) *Bob-Whites and a School Feeding-Shelter:* How can you find out the best way to build a feeding-shelter? How are you going to teach a covey of bob-whites to come to the shelter? Use such expressions as thicket, food supply, a natural cover, brambles, wind proof, bevies, clutch, "freeze," brood, hiding, southern exposure, and natural appearance, in writing your report. Your report should be reliable and valuable enough to be used by schools contemplating such a project.

(6) *Bob-Whites and Sportsmen:* What is a hunter? What is the percentage of hunters to other population in Ohio? What is a sportsman? A conservationist? What is the Isaac Walton

League? What are its aims? Interview several sportsmen and members of the Isaac Walton League. Make a list of constructive things sportsmen have done for bob-whites. Are all sportsmen conservationists? Why do sportsmen feed bob-whites? Do they all feel the same about the protection of the bob-white? How would you answer the argument that sportsmen supply the state with money which should make it possible to shoot these birds. Weigh the claim of the hunters that the small fee paid for a license gives the hunter a right to shoot the birds which is superior to the right of others to enjoy them. Present a fair picture.

(7) *Bob-Whites and "Killers":* Are all "sportsmen" the same as "killers"? How many gunners ranged the Ohio Woods and fields last fall? Can you name an army of about the same size? What is your authority? Suppose that the number of quail killed exceeded the increase? What is meant by high-powered, rapid firing, repeating guns, rifles, shot guns, harried, crippled, "setters," "pointers," poaching, violation of law, a blanket open season, and flushing? Compare the merits of a state-wide open season and an open season by counties. Write an honest report of your findings. The words listed are suggestions and may be used if necessary.

(8) *Bob-Whites and Their Natural Enemies:* What animals, besides man, are enemies of the bob-white? What are predatory animals? Vermin? What would be necessary to prove that an animal kills bob-whites? What is meant by scientific evidence? Would hearsay be sufficient? Arrange the enemies in order of effectiveness. In what way are they an enemy? What is the source of your information? What is the effect upon the survival of the bob-white of being hatched on the ground? Of being a ground bird? Of being precocial? How would an insurance agent size up the probable life span of a bob-white? How does the number of eggs laid indicate the probable annual mortality?

(9) *Bob-Whites and Sanctuaries:* Keep a record of all conferences held. What is a bird sanctuary? Where is the nearest one to your school? Are cemeteries bird sanctuaries? Colf courses? Metropolitan parks? City backyards? Check any of the following that you consider necessary for a bird sanctuary, and particularly for bob-whites. Cross out anything that you consider undesirable. Underline anything that you do not consider necessary, but at the same time you feel that it is desirable.

Bird houses	Underbrush
Lake or brook	Brambles
Feeding shelves	Fallen logs
Marble statuary	Brush piles
Daily visitors and bird classes	Pollution
Several house cats	Swamps and bogs
Short open season	Pole traps
Management	Steel trapping
Shelters	Winter range
Weeds	Winter feeding

(10) *Bob-Whites in the Backyard:* A backyard can be a sanctuary. Some backyards are sanctuaries. I recently received a letter which reads as follows:

"I have about twenty bob-whites come to my place daily. I put buckwheat out for them, and they come up to the back porch and at times on the porch. One becomes so attached to them that I feel it my duty to feed them as though they were my own."

Another letter said this:

"A few years after graduating from Normal School, I became an invalid. You can never know what my course in bird study has meant to me. I have made no profound discovery, but my diary is a record of real friendship. The yard has been planted with wild berry bushes which offer abundance of food for the birds. The bob-whites come to a feeding station which is but five feet from the window. Each day I see something new happen. These are the brightest hours of the day."

Make a list of people who feed bob-whites in their backyards. If you obtain a goodly number plot the results on a map. Have them write a letter telling you why they do it. These are human interest stories that usually do not get into the press. They do not make such a loud "report" as a gun, and yet, perhaps they should be "brought to the fore."

How can you defend the position that it is right to protect bob-whites for their cheery call? To study their interesting habits? For their companionship?

(11) *Bob-Whites and Game Farms:* Are there Ohio Game Farms? If possible, visit one. Are bob-whites ever raised in captivity? In Ohio? For what purpose? Should tame birds be released for the hunting season? Why? Should the State of

Ohio raise bob-whites to release for hunting? Should the Texas quail be introduced into Ohio? Make a list of a few principles for the management of bob-whites as game. What is your conclusion?

(12) *The Bob-White and Free Rights:* Hunting, fighting, and killing are instincts that go back to cave days. So also is the belief in the rights of free speech, freedom of the press, liberty to rove through the woods, and ownership of wild life. In England wild game is the property of the lords who own the land. In America wild game is the property of the state and hence of the people. This is our heritage. It is a basis for our thinking. That, however, is not the whole story.

As civilization advances our free rights become restricted. We have a right to liquor, but not to endanger the lives of others. Likewise, it has come to pass that although we have a right to shoot black duck it has to be in season. We can shoot wild geese in the fall, but not in the spring when they are on the way north to their breeding grounds. During open season, we can kill two cock pheasants a day in Ohio, fifteen ducks, and twenty-five coots. The game hog still has a chance for fifteen ducks and twenty-five coots although it would appear to be more than one individual should possess per day. There is no open season on hen pheasants, wood duck, cackling geese, and bob-whites. Every time rights are restricted, there is opposition. If all of the present-day restrictions had been put on in Colonial times, it would have done no good. Along with prohibition must go public opinion and education. This fact has also been brought home to us recently after considerable bungling and experimentation.

Until education catches up with the instinct to kill, there must be game for the sportsman. Then again, since to a certain extent he foots the bills, he is entitled to some returns on his investment. There are several reasons why the pheasant, rather than the bob-white, should fill this need. Collect your data, and write a paragraph to support the idea that the pheasant should hold the position of upland game bird during the next decade.

(13) *Bob-Whites and Game Laws:* What is the duty of a conservation commission? Of game wardens? How do they obtain their appointment? What is meant by civil service? If you have opportunity, try to find out what your representative knows about the bob-white situation. Who proposes new laws? What is meant by coming out of "Committee"? What committee

would recommend new bills relating to the bob-white? What bodies would have to approve the bills? What action would be necessary on the part of the governor? How would you draw up a set of resolutions? How would you make a petition? To whom should they be sent? Why do people send petitions? Of what value are petitions? What are the present laws relative to bob-whites? Are they wise laws? Write a clear statement of your findings, Use expressions as: no open season, non-resident citizen, bag limits, possession, and interstate transportation.

(14) *Bob-Whites and Human Thinking:* If you have been using the scientific method, it is as though you "come from Missouri" and have to have facts before you accept any statement. If everyone used the scientific method, this world would be a much better place in which to live. Suppose someone says: "Shooting is necessary to scatter the flock and thereby to prevent inbreeding." That is possibly good logic, but it is poor science. It implies that when the flock is scattered, they will not come together again. This assumption is incorrect. People who have observed know that the covey comes together again and later breaks up for breeding. Then again, inbreeding does not mean degeneration. It is by inbreeding that we are able to keep our pure breeds of cattle, poultry, dogs, etc. Doctor S. Prentiss Baldwin meets the question by asking a question. He asks, "How did the bob-white get along before they were scattered by shooting?" In other words they were healthy before man disturbed them.

Suppose someone says that bob-whites are not as healthy or not as large as they were before they were placed on the song bird list. Ask a few pertinent questions. Discover what the scientific method was by which they arrived at the conclusion. How many birds should be recorded to prove the point? Were the birds measured or weighed? Would fatness or thinness be proof? How would you determine whether bob-whites are decreasing or increasing or holding their own?

Suppose that someone says that they wish to shoot the bob-white for food. How much does ammunition cost? How much does one bob-white weigh? How much does a bob-white weigh when the viscera, feathers, and other non-edible parts are removed? Suppose that the gunner kills a bob-white every time that he shoots. How much does one bob-white cost? What food could be purchased for the same amount of money? Does the amount of food obtained warrant shooting the bob-whites?

(15) *The Bob-White for the State Bird:* In 1934 the Ohio Legislature rushed through a bill making the cardinal the State Bird. The cardinal is the State Bird for two other states, namely Kentucky and Illinois. Ohio is noted for work that has been done on the house wren, and it is a progressive state in placing the bob-white on the song bird list. These birds should at least have a hearing. Have a school debate on the State Bird for Ohio. After the debate let the students vote. We would like to know what birds were candidates, the arguments, and the results of the vote. We hope that Ohio will treat well the bird of its choice.

(16) *Bob-Whites and Conservation:* The last passenger pigeon died in Cincinnati, on January 1, 1915. Our policy regarding the passenger pigeon was foolish. Write a paragraph on that policy.

What is the value of a conservation commission as compared with a conservation commissioner? How many of the following should be represented? A farmer, a sportsman, a scientist, a teacher, a Republican, a prohibitionist, a clergyman. Do you recommend civil service for this? Explain. Now that the evidence has been presented and weighed, the class should be in a position to make general conclusions about the stewardship of the bob-white. Write a paragraph or more on the class bob-white policy.

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"POWER ALCOHOL" LEGISLATION PUSHED IN SEVERAL WESTERN STATES

Gasoline will be "spiked" with alcohol made from surplus farm products in a number of states in the West, if pending legislation fares generally as well as it has in South Dakota, where a bill to that end has already passed both houses of the Legislature. No national legislation on the subject, however, is at present contemplated, so far as is now known.

Among the states where "power alcohol" legislation is now under consideration are Iowa, Minnesota, Nebraska, Idaho and California. Other grain belt states are said to be preparing to join the procession.

The proposal to encourage addition of alcohol (usually ten per cent by volume) to gasoline, either by direct legislative requirement or, more often, by favoring tax differentials, has been agitated for some years. The claim is made by the proponents of the idea that with present engine construction and carburetor adjustments motor vehicles and tractors can use to advantage gasoline containing up to twenty per cent of alcohol. Farm organizations have a stake in the legislation, since it promises a profitable way of using up surplus produce, especially off-grade grain unsuitable for feed or market and cull fruits and vegetables unfit for food.—*Science Service.*

SERVICE TESTS FOR CHEMISTRY[1]

BY B. CLIFFORD HENDRICKS, *University of Nebraska*
AND O. M. SMITH, *Oklahoma A. and M. College*

The teacher of today makes use of many facilities such as blackboards, projection lanterns, speaking movies, demonstration desks, exhibits, laboratory manuals, and libraries. The most common of these is the textbook and its most important adjunct we believe to be "tests." It is to be noted that all of these, exclusive of tests, are made by some one other than the teacher, and are passed to the teacher to help him to give more efficient instruction and to enable his students to progress more rapidly.

Teachers are generally reconciled to the use of all of the above aids in teaching chemistry, but there is a too generally aversion to the use of "factory-made" tests. There seems to be an unreasonable assumption that testing is a God-given prerogative which, once the teacher releases it, he will have lost one of the fundamental privileges of his position. Do we as teachers pride ourselves in teaching chemistry so much better or so differently that tests made by others are not fair to our students? Or is the preparation of an examination a more personal undertaking than that of preparing a textbook so that we insist upon writing our own tests but delegate textbook writing to others? Is a teacher any less a teacher who *chooses* tests prepared by specialists than he who insists upon *writing* his own? Is the preparation of test requirements so much simpler than the writing of textbooks that, even though untrained, all teachers can write tests but very few can write successful textbooks?

It seems to us that the answers to the above questions necessitate an agreement upon the purposes back of testing. Why do we give examinations? Others[2,3] have answered this question but a reëmphasis may be in order. Put in the fewest possible words, we test to measure the student's knowledge, ability and his rate of achievement. We wish to learn if we have made the changes in the individual that we started out to accomplish. Before we can measure or test, we need to deter-

[1] Presented before the Division of Chemical Education of the A. C. S. at Cleveland, Ohio, September 11, 1934.

[2] K. M. Persing, "The New-Type Examinations in High School Chemistry," *J. Chem. Educ.*, 8, 2227–37

[3] Amos G. Horney, "Testing the Achievement of Students" in Chemistry, *J. Chem. Educ.*, 11, 360–366 (1934).

mine definitely and agree upon that which we are to measure. We must define what chemistry teachers are aiming to do in their courses that tests prepared may indicate the degree of their success. One of us[4] has tried to secure an answer to the question, what are the aims of chemistry teachers? While, as might be expected, there is no universal agreement among all teachers as to their objectives, there are a number of aims which received the approval of seventy-five or more per cent of some two hundred teachers consulted. These aims include: Providing the students with an understanding of the world in which we live; a knowledge of natural laws; a knowledge of the significance of cause and effect; an ability to draw generalizations from specific experimental data; training in the scientific method of thinking, and training in ability to apply important principles of chemistry.

If these are some of our objectives how well have we succeeded in teaching our students the significance of cause and effect, or the ability to generalize or skill as scientific thinkers? Would not most of our evidence be sadly lacking in objectivity? Why so? Largely because our conventional tests indicate such abilities only indirectly. Most teachers are agreed that tests which actually measure these abilities are difficult to prepare. If there are to be such examinations skilled help in building them is going to be in demand. In other words here is a need for "factory-made" tests. It is no reflection upon a teacher that he goes to competent help for that which he is unable to do for himself. He goes to the author and the publisher for his texts, the glass blower for his glassware, to the instrument and tool maker for his balance and calipers, and to the manufacturer for his chemicals—to all of these for their skilled assistance in preparing the tools of his laboratory or classroom. His task is to teach, his tools should be any aids available for the purpose, his product a trained individual. This paper is a plea for a new tool, the modern test, constructed, tried, and standardized by chemistry teachers and experts skilled in test making.

A start has been made in constructing measures of some of these intangible objectives. Attention is called to work in progress under the direction of the Cooperative Test Service of the American Council of Education. In the subject of

[4] O. M. Smith, "Objectives in the Teaching of General College Chemistry," Unpublished Manuscript.

Zoology tests on ability to infer[5] have been formulated and are in the process of refinement by use. In a similar manner[6] tests to measure ability to use the scientific method in the subjects of botany and zoology are under construction. Tests to ascertain the ability of students to apply the principles of chemistry[7,8,9,10] have also been attempted and are still under trial in provisional forms.

There are some who insist that they teach the *subject matter of chemistry*. Appreciations, abilities, habits and skills are to come only incidentally. Such teachers propose to bear down on the fundamentals of our science; the laws and principles. Are such teachers out of the market so far as "factory-made" tests are concerned? An analysis of test questions[11] prepared by such teachers indicates many respects in which they could be greatly improved. Some teachers achieve improvement by compiling a list of their best questions from year to year from which they secure help in building examinations. One of the authors not only has such a question list but in addition has upon each question a scatter chart of its answers from a hundred or more of his students as an index of its difficulty. But is not such a practice a tacit acknowledgment of the assistance which ready-made questions may be to the teacher who is preparing his examinations? But why confine our selection only to our own lists? Why not exchange best questions? Or even try out some "factory-made" questions?

Whether we believe in chemistry as method or as content or both, the use of tests built by experienced test makers offers to the ambitious teacher a variety of indices of the outcomes of his teaching. Like modern instruments, these "factory-made" tests emerge from the "proving ground" with their performance at least partly demonstrated. Among the uses which such tests share with so-called essay tests may be listed:

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[5] Ralph W. Tyler, "Measuring Ability to Infer," Ohio State Univ., *Educ. Research Bull.*, 9, 475–480 (1930).

[6] Ralph W. Tyler, "Ability to Use Scientific Method," Ohio State Univ., *Educ. Research Bull.*, 11 1–9 (1932).

[7] Fred P. Frutchey, "Measuring Ability to Apply Chemical Principles." Ohio State University, *Educ. Research Bull.*, 12, 255–260 (1933).

[8] B. Clifford Hendricks, R. W. Tyler and F. P. Frutchey, "Testing Ability to Apply Chemical Principles," *J. Chem. Educ*, 11, 611–613 (1934).

[9] Amos G. Horney, Loc. cit.

[10] B. Clifford Hendricks and R. W. Tyler, Testing for a Mastery of the Principles of Chemistry *Sci. Educ.* 18, 212–215 (1934).

[11] B. Clifford Hendricks, "New-Type Tests Meet a Need," *J. Chem. Educ.*, 4, 1418–1423, (1927).

1. Determining the student's advancement and what needs yet to be taught, or giving a continuous audit of his progress;
2. In furnishing incentives to study and stimulating student efforts;
3. In the diagnosis of the weakness of students and the difficulties of the subject matter;
4. In evaluating the abilities and strength of teachers;
5. In evaluating different methods of instruction and administration and in testing different techniques for educational research;
6. In making comparisons of student advancement and teaching practices for different classes, different schools and different geographic sections.

Many teachers of chemistry were attracted to science by the appeal of its experiments. As they advanced into an understanding of the subjects they were impressed more and more by the efficiency of the experiment as a tool of progress. Lavoisier broke the strangle hold of the phlogiston theory by the use of the balance. The complexity of the atom has been revealed by the X-ray. Why not carry this habit of experimentation over into our teaching activities? In testing there is opportunity for such a departure from routine. Many teachers dislike so-called objective tests,[12] possibly because they are different. They say, "We have never used that form of examination," therefore, they hesitate to change. Moseley might have said the same thing of the X-ray but he tried it and we credit him with the concept of atomic numbers because he was willing to experiment.

It has been said, "No one pretends that objective (or any new form) tests are a panacea for all the ills of teaching, yet it certainly is unwise to neglect a good tonic because it has been put up in a badly shaped container"[13] "Factory-made" tests will be found to have their weaknesses just as textbooks vary in their quality, but if we can look upon these tests as teaching tools to be used and improved, that very attitude will increase their service for us.

The most effective assistance in test construction is the intelligent trial of the product. It is urged that we, individually, give these new teaching tools, as they are prepared, the same trial as we do to a new inhibitor, colorimeter or improved electrometric titration apparatus.

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[12] W. F. Hoyt, "New-Type Methods of Testing—A Criticism," *J. Chem. Educ.*, 4, 1414–1417 (1927).
[13] H. W. Fawell, *The Am. Physics Teacher*, 1, 100–104 (1933).

THE CRISIS IN HIGH SCHOOL AND COLLEGE MATHEMATICS*

By Paul S. Dwyer
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There are a number of crises which concern the teachers of high school and college mathematics. There is the crisis, for instance, brought about directly by the breakdown of our economic machinery which makes it difficult, and in many cases impossible, for us to secure those funds and equipment which are necessary for effective teaching. Many feel there is another crisis present in the field of the foundations of mathematics where there seems to exist a disagreement among leading mathematicians of the world as to what mathematics really is. The October issue of the *American Mathematical Monthly*, for instance, carries an article on this subject entitled "Is There a Crisis in Mathematics?" Yet another crisis seems to me to deal with the position that mathematics should have in high school and college studies. Though these crises are to some extent related, it appears to me that this third problem is the one which most directly concerns us and which, in the last analysis, we must solve.

It is this last crisis which I aim to discuss in perspective. However, there are certain limitations to my approach which I should indicate. As a college teacher I am interested primarily in the mathematical training of those students who are preparing for college. In the suggestions that I have to make, I have this group of students largely in mind. I hope, however, that some of my suggestions will also be worthy of application to those students who are not, primarily, preparing for college. I should indicate also, although I hope it is not a limitation, that the approach which we have at Antioch is not the same as at more conventional colleges, so I should not present my views as being representative of college teachers of mathematics.

Another limitation of this article is that of compactness. I shall attempt, however, to keep the basic points before you so that this compactness should not cause much serious difficulty. What I have to say will center around the following points:

1. The present tendency is to give mathematics a less and less important place in high school and college.

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* An address given before the mathematics section of The Central Association of Science and Mathematics Teachers, Nov. 30, 1934.

2. The continued progress of knowledge demands, more than any other single thing, more and more mathematical training.
3. There are certain changes which we must make.
4. I shall attempt to interpret these suggested changes by showing the techniques we have worked out at Antioch to put them into effect.

With reference to the first point I presume that most of you feel this trend away from mathematics. I shall not attempt to establish this trend because I imagine you all sense it and it is just a bit difficult to measure. To satisfy my own curiosity I made a study of the amount of mathematical entrance credits of Antioch freshmen during the interval 1921–34. Although in some respects this was not a fair statistical study, I found that the average for each year was between five and six semesters with no appreciable trend except that trigonometry accounts for a slightly increasing percentage of the total.

I have come to the conclusion that direct means of measuring this tendency are not so valuable in understanding it as is a study of the educational philosophy which has caused it. The classical education of a century ago stipulated an extensive study of languages and mathematics with the primary objective of training the mind. During past decades, however, under the leadership of those who are convinced that there is no transfer of training, there has been an extensive reaction from the classical point of view to a more utilitarian one. This reaction, which seems to be still going on, has effected the classical languages more than mathematics, since mathematics is known to have great utility in many fields. The Antioch curriculum, for instance, has no formal courses in Greek and Latin, while one year of mathematics is at present required of all students.

I think that most of us would admit that the reaction from the extreme classical education has been a healthy one even though formal mathematics has lost greatly in the process. Personally, however, I am not completely convinced by the results of these experiments, which have been performed on the transfer of training. I feel that the interpreters of these experiments have generalized too broadly from the results they have established. I believe that the scientific position of the future, when the results of more complete experiments have been made available, will be somewhere between the old classical viewpoint and the modern utilitarian one. I believe that knowledge,

if it is really assimilated in the personality, changes that personality. The present science of learning, however, says to the average man "There is no transfer of training," so, as a practical measure, it is utterly foolish for us to advocate the transfer of training as a principle in curriculum building. If we do so, we only tend to convince our critics that we are hopelessly out of date.

There is another factor which at the present time is increasing this distrust of mathematics. It goes back indirectly to the present social and economic upset. The World War and the subsequent world depression have caused an increased interest in economic and social studies. This development has led, sometimes unconsciously, to a desire for less emphasis upon the more highly developed studies of physical science. Sometimes this trend has been conscious, for there are keen analysts who have come to the conclusion that highly developed physical science has been a handicap rather than an aid in solving man's real problems. There are others who, although they realize the value of highly developed physical science, sense the immediate need of developing social and economic techniques and so actually propose a vacation from physical science. These ideas have permeated the country so much that Dr. Karl T. Compton, Chairman of the Science Advisory Board, has felt it wise to make a more or less official reply for physical science.

Now the chief application of mathematics, as commonly understood, is in the field of physical science, so it is quite natural to expect that these critics of physical science would feel that it is a serious mistake to teach mathematics to a large proportion of the students in high school and college. This, it seems to me, is the real reason for the growing distrust of mathematics. These are effective arguments and we must face them squarely.

I submit that the fallacy is in the assumption that mathematics must be tied up with physical science. Physical scientists are too apt to look upon mathematics merely as a tool with which they work. Others have accepted this view. As long as we are so uninformed and careless that we do not attempt to destroy this impression in the popular mind, we can expect to find a growing tendency toward less and less mathematics.

Mathematics should not and need not be tied up with the field of physical science; in fact it should not be tied up with any field at all. In this way it may have wide applications to

all fields of knowledge where its methods are pertinent, hereby avoiding that monopolistic attitude toward it which physical science has now.

I should like to take time to explain something of the changes which have occurred in the concept of the nature of mathematics. I can only indicate here that there has been a great change. Although mathematicians are not entirely agreed as to what mathematics is, yet there has been a change from that definition which indicates that mathematics is the science of number and magnitude to that which says that mathematics is the science concerned with the logical deduction of consequences from the general premises of all reasoning. It is to be noted that the newer definition is not concerned primarily with physical science.

I should note in passing that I do not wish to attempt to minimize the value of mathematics in the study of physical science, nor the study of physical science itself. I cannot see how any modern person can pretend to think himself informed if he does not have some understanding of mathematical material through calculus, for much of our material civilization would have been impossible without a Newton and the calculus. In order to support this point of view I should like to quote from an article which appeared some years ago upon the editorial pages of the *Saturday Evening Post*, a paper which certainly has no mathematical bias.

> Unfortunately for the casual and easily daunted reader, modern science is written in the language of mathematics, and in the dialect of calculus; not only physics, chemistry, and electricity, but physiology and other life sciences. Lack of easy familiarity with higher mathematics is a formidable obstacle between our ignorance and any real grasp of the modern conception of the universe we live in; and this obstacle will continue to bar our paths until the extraordinary importance of mathematical studies receives full and practical recognition.

To continue with the main argument, however, mathematics has freed itself from the realm of physical science and is in a position to develop along any lines that seem wise. We may have as many types of mathematics as we please (as long as they fulfill the requirements of logical consistency) and any one will be just as "true" as any other. There is nothing inherently right, for instance, about the axiom that the whole is equal to the sum of all its parts. However, this postulate, as it is now called, is distinctly inapplicable to many problems in biology, psychology, or economics, although it is extremely useful in

physical science. I venture to suggest that one real cause of the relative lack of advance of the non-physical sciences is the fact that the old mathematics developed for physical science is inapplicable to them. A necessary condition for their advancement is the development of new types of mathematics better suited to their needs.

As all this may seem rather indefinite, I should like to present a description of a new type of mathematics which is growing up and which is beginning to make great contributions to nonphysical science. There are comparatively few who sense its significance and the rôle it is going to play in building up the science of the future. For want of a better term, I shall characterize this development as the mathematics of mass measurements. Perhaps it appears that I should use the term "statistics," but what I have in mind is something more than the collection and tabulation of masses of measures. The method of mass measurement bears to statistics, as commonly interpreted, about the same relationship that the complete scientific method does to inductive experiments. It is necessary here not only that these masses of figures be recorded, but that they be checked against each other for total or partial consistency. Since a large number of factors may have featured in each of these measures, it is necessary to use quite complicated analytic methods in order to discover the effects of any individual one. This can best be done by mathematical reasoning and the results can be interpreted best in the light of the theory of probability, which plays as important a rôle in this new mathematics as calculus does in physical mathematics.

Although this method is relatively new, it is being applied in many fields. One of its most perfected forms is the science of insurance. No science of this type could have developed on the basis of individual measurement and prediction, but a science with great social use has been built upon the probability-statistics method.

All sorts of general relationships in the fields of economics, biology, and psychology are as yet undiscovered. Many of them await only the attack of those trained in the new mathematical methods designed to study partial relationships. Our people, ignorant of these techniques and the unique contribution which mathematics can bring to the development of economic and social science, are turning away from the one thing which gives promise of a real advance. This then constitutes a real crisis. It

is not that we are in danger of losing our jobs, not that mathematics is being pushed out of high school and college curricula, but that civilization in its hour of need is turning away from the aid that gives promise of success.

What can we do about it? First we must recognize that the responsibility for the present situation rests to a large extent on us for we are failures if we are unable to show our students that the study of mathematics is valuable to them. The judgment which is being rendered against mathematics is, in part at least, the judgment of our former pupils.

I am not entirely familiar with the attitudes of the high school teacher, but I have come to feel that the teacher of college mathematics is not willing to share the blame nor to meet the real points at issue. For example, at the meeting of the Ohio section of the Mathematical Association of America last spring, this whole question was raised by teachers from the University of Cincinnati, because, as they reported, Cincinnati was removing geometry and perhaps algebra from the list of high-school required subjects. In the discussion which followed, the blame for this situation was placed on the inadequate mathematical training of many high-school teachers. Now I think that this is an important point and I am sure that the criticism of the extensive educational requirements which are crowding out real professional training, is justified. I feel definitely, however, that any attempt to solve this crisis on that basis alone is utterly futile. We must make sure not only that our teachers have adequate professional training, but also we must understand why the average citizen is gradually becoming convinced that mathematics is nothing but a silly ritual at a time when it is becoming more and more useful in solving all kinds of questions. We must convince him through needed reforms in our teaching and attitude that mathematics is not a silly ritual, but rather is as indispensable in his logical quantitative thinking as is his automobile in transportation.

Next I suggest that we must understand something of the nature of mathematics and its relationship to the changes which are occurring all around us. We, as teachers, must have not only the viewpoint of the pure mathematician, a real artist who is not primarily interested in mundane and utilitarian views, but at the same time we must have the viewpoint of the one who has applied mathematics to physical science, and perhaps most important of all in this day and age, we must sense the

imperative need of directing our powers to the discovery and measurement of many non-physical relationships which await the attack of those who are trained in these mathematical and statistical techniques which are becoming available for the reduction and interpretation of masses of partially conflicting evidence. If we are going to help we must be thoroughly acquainted with these techniques and also with the subject matter susceptible to the new attack so we can show our students how they can make use of mathematics in these newer fields. Many of the present teachers in these fields, lacking the mathematical training, are unable to do this. Some psychologists, for instance, are much interested in the work which Dr. Thurstone has done in *Multiple Factor Analysis* and are aware that the methods he has developed will have wide application, as he has shown with his interpretations of the *Strong Vocational Interest Tests*, but comparatively few of them have that background of mathematical training (theoretical statistics, theory of determinants, and a certain degree of mathematical maturity) which would enable them to comprehend fully what he has done or to carry on the work which he has so brilliantly started.

The next definite suggestion is that we must emphasize the utilitarian value of the subject matter, even to the extent of sacrificing some of the subject matter itself. Each teacher must understand not only the subject matter he is teaching, but the reasons, and specific ones, for teaching this particular subject matter. I do not agree with those who advocate that a student should never be pushed into a certain field of knowledge until he has developed an intense desire for it, but I do feel that the student should always be informed of the eventual applicability of what he is studying.

Every teacher should make an outline, at least in his own mind, of a wide variety of specific instances in which the item under study is needed so that he can make his subject vital to his students. It is important that the teacher make most of these selections from his own experience and it is imperative therefore that he have adequate experience and understanding of the rôle that mathematics is coming to play in modern life.

Also we can make use of a principle which I call the "transfer of interest" which I can explain best by means of an example. Many engineering students, because they have been convinced by teachers of engineering that mathematics is most vital to them, frequently take great interest in mastering college math-

ematics even though they cannot, in the very nature of things, understand the full significance of what they are doing each day. Now this technique, which is a very valuable one, must be used most cautiously and must not be abused. It should not be used to cover up our ignorance of the utility of what we are teaching, but rather to supplement our explanations, which the student cannot fully comprehend at the time because of a lack of perspective. Within these limits, it seems to me this is an extremely useful technique which could be used effectively in working with students who are preparing for college.

I am trying to indicate that this utilitarian appeal need not be as narrow as some would have us think but, if mathematics is to keep its place in the modern curriculum as a required course, it must demonstrate its worth on a utilitarian basis.

Perhaps it will appear that this emphasis upon utilitarian appeal will lead to the conclusion that only the application of formulas should be studied and their derivations should not be required. I cannot see that this argument is valid for, in general, we can only use those things which we really understand and we can only understand a formula if we have seen how it is built up, with design, out of its constituent elements. I do think that we have sometimes made a fetish out of "proofs," and that there may be occasional times in the student's development when it is better to omit the proof than to demand an extended type of reasoning or a degree of rigor for which the student is not psychologically prepared.

This leads me to the next suggestion which is that we must recognize that there is a direct conflict between the nature of mathematics and the psychological methods of instruction which should be used in teaching. For the psychological method demands that the general proposition be inferred from specific cases while the use of mathematics calls for the application of the general proposition to the specific case. To put it another way, mathematics is deductive logic while inductive presentation is called for in the learning process. Our inability to sense this conflict, and to meet it, is partially responsible for our failure to make mathematics vital. It is necessary for the teacher to call on the inductive spirit of the student, but at the same time, he should be developing in the student a sense of, and desire for, the deductive methods of mathematics. In my opinion this desire for logical deductive thought is perhaps the most significant indication of a mentality which is becoming adult.

I feel that the teacher of high school geometry, since he teaches the subject where this transition is best made possible, is perhaps the most important teacher in the whole educational plan from kindergarten through college.

Mathematics is both the hardest and the easiest subject to teach because it can be most easily counterfeited. A continued use of rote learning will sometimes enable one to present the appearance of mathematical mastery. The student, too often, does not sense the difference between the genuine article and the counterfeit and we, as teachers, have not been too successful in showing him. But the crime is that sometimes the counterfeiting is a distinct part of the educational system, as for instance, the assigning of a teacher to a class in mathematics because it is easier for him to "get by" in that subject. It is probably unnecessary for me to hint that the athletic coach is sometimes given this type of assignment. Such a system is so vicious, so utterly devoid of common sense, and the results so meager, that it is a surprise that the public has not turned on us long before this with more specific attacks on our silly ritual. Personally I think it would be better for the student to be exempted from his mathematics than to take it under the direction of some one who is attempting to teach it only because he can counterfeit it.

Another suggestion is that we must see that the student learns his subject thoroughly. Thoroughness means much to the mathematician since he, more than anyone else, must build on previous results. Yet the complete mastery of material, as modern psychology is showing us, involves much repetition over a period of years. Frankly I cannot see that we have made much attempt to follow up the learning process and to see that certain material is really assimilated by the student.

The students, which you send to us, show few signs of having spent between five and six semesters in the study of high school mathematics. On the first day of the fall term I gave my class of freshman students a little quiz in algebra. Exactly one half of them were unable to evaluate $a/b+c/d$ properly. And lest you think that our students are exceptionally stupid, I might state that we have plenty of proof, as revealed by various objective tests which have been given to Ohio freshmen, that our freshmen are as well prepared as those in any college in Ohio. And this particular class in trigonometry was composed of seventh and eighth Antioch decile students. You see the situation

is such that we who teach in college cannot assume that a student who presents to us certain credits in algebra, geometry, and even trigonometry, knows anything at all. Moreover, it is not so much the fact that he may not know anything that is bad, but also that he doesn't know how to study, and has never learned the meaning of real application. In some cases I feel that his high school mathematical training has been a handicap, rather than an aid, to his further mathematical development.

Now I am aware of the almost impossible situation which confronts the high school teacher and I do not wish to be insensitive to conditions. I have, however, two definite suggestions which I think can be used even now. First I feel that a definite line should be drawn between the student who is preparing for college and the one who is not. It is not so much that I am advocating a different type of subject matter for the college student but that I feel that he should be held to a type of thoroughness in his mathematical studies which is not so important with others. In the larger high schools sectionizing within groups can also assist, but sectionizing should be on the basis of ability so that teaching methods and standards could vary with the sections.

A second suggestion is that, particularly for the college preparatory student, we should have a simplified mathematical curriculum. I do not favor under present conditions the giving of high school trigonometry to these students. I would rather suggest another course in the addition of fractions or perhaps (and this would be valuable to other students as well) a course in business arithmetic. We at Antioch can usually make headway with our students if they understand and can use simple algebraic operations through quadratics, if they really understand what is meant by geometric reasoning and if they have learned what it means to study.

I have spent a large enough portion of my time in making general suggestions and should take some time to show you just how we are putting them into effect at Antioch. Now I recognize that the same techniques will not be equally applicable to high school and college courses, but I hope that a brief description of what we are doing will be of value to you.

It is perhaps surprising that a school such as Antioch, which is known throughout the country as being opposed to "silly ritual," has found it wise to keep mathematics as a required course. Frankly there are some at Antioch who think that

mathematics should not be required of all college students. I should say, to give proper perspective to the situation that about one third of the work of the work of the Antioch student is composed of rather varied required subjects. If, as at present, mathematics continues to stay on the list of required courses it will be only because the faculty is convinced of its value. In order to maintain that conviction of the faculty, we have thought it wise to make various innovations in line with my suggestions above. Let me describe them.

We start off before registration with tests which will enable us to discover just what the entering student does know. On the basis of the results of these tests and all other available information and frequently after an individual conference, the student is signed up for some section of either technical or cultural mathematics. The technical course is designed for those students who want the course in trigonometry, analytic geometry and calculus which is required of those students who expect to major in science. The cultural course is required of all other students and so is looked upon as *the* required course. The techniques we have worked out differ for these two courses so I shall discuss them separately.

The technical students are further divided into sections on the basis of these pre-registration tests and in addition, during the first week or two of the semester, additional diagnostic tests, largely in algebra, are given so we can see just where we need to begin with each student. At this time the student secures a syllabus which outlines the important algebraic and geometric theory and techniques which we feel are absolutely essential to further work in mathematics. The student is instructed to use this in filling up gaps in his mathematical training, gaps which the tests are bringing to light. In order to see that the student really masters these techniques we put into effect immediately what we call "the system of x's," a quiz and checking system described later.

In this manner we are able to locate exceptional cases at the top and bottom of the group and also we are able to know just what each student is or is not able to do. We then have conferences with each student whose situation demands immediate attention. We make appropriate suggestions to the student who knows little algebra yet still wishes to stay with the technical program and we try to give him a fair picture of what he is up against. If a student shows some considerable knowledge of al-

gebra and trigonometry, on the other hand, we give him further diagnostic tests in trigonometry so that he will not be required to repeat material which he has thoroughly mastered. Occasionally we find a student who has had a course which is the equivalent of the college course in trigonometry, and we attempt to work out a special program for him. This type of diagnosis all takes time, but we are convinced of its value.

The chief point which I wish to bring out with reference to our technical program, however, is our attempt to see that the student has complete mastery. The student is asked to spend two hours of preparation for each hour of class and to report to us how much time he has spent, for we find a wide variation from the required amount is significant. He is also asked at the beginning of each class meeting to turn in the solutions for a number of problems designed to illustrate the current principles. If his results are not correct, he is asked to rework the problems and to continue to do so until all are correct. In addition we give him frequent examinations, called x's, at the regular class hours in which we ask him for current proofs and for the solution of typical problems. These x's are marked right or wrong, are recorded, and returned to the student. He understands that he is to make up each x that is incorrect, that is, he must present himself to the instructor during office hours for further examination on each topic that he has missed. This examination process is continued until the instructor is satisfied that the student has mastered the points at issue. The system is not developed on a sampling basis, as is the final examination, but by a continued examination of all the basic techniques and theory of the course.

Now the administration of this system demands a huge amount of work, but it has certain advantages. Not only does it insure thoroughness, but it combines, to a certain extent, the group method and the method of individualized instruction. In the technical program it is necessary that certain material be definitely covered on schedule so the class moves along as usual and the individual student is forced to work out his difficulties with the instructor in the spirit of individualized study. Adequate check-ups are made frequently so as to insure reasonable proximity of class and make-up work while adjustments are made in the student's program if he gets too far behind. There is a general improvement throughout the year as the student learns the system and the techniques for carrying it out. The

most encouraging thing about the whole method has been the spirit which the students have shown once they understood what it was all about. The system could not have worked without their cooperation. In spite of the fact that, particularly during the first part of the year, the instructors are almost driven to nervous exhaustion, I do not feel that it is too big a price to pay for the exaltation that comes to the student who feels, for the first time in his life, that he has really mastered something.

In our technical course we have prepared a syllabus in which the theorems and formulas as well as the skills and techniques have been stated and numbered for reference. We are attempting to keep the material we present on a utilitarian basis by presenting these syllabi to departments which require this course of their students. We ask these departments to indicate such material as is useful, or not useful, to them. We have not been able to eliminate much of the conventional technical material in this way, but rather have found that the physics department wanted the addition of hyperbolic functions and that the psychology department wanted the addition of some elementary statistical material and we are now attempting to find a place for this. The important point is, I think, that we have a greater sense of the value of this material and are probably better able to pass this sense of validity on to the student.

But I must pass on to the cultural program for it, too, has its points of interest. We were not at all satisfied with the results of our more or less typical freshman course, so we decided to change it. Some five or six years ago, Professor J. D. Dawson, who is now in charge of the educational work of the Tennessee Valley Authority, set about the work of reorganizing the course. He prepared his own text, which includes in its list of contents such practical subjects as measurement, computation (using adding machines as well as logarithms), applied analytic geometry, elementary statistical concepts, and fundamental principles of investment. Not all of these subjects are necessarily studied by any one student, for again we attempt to see that he does not waste time on material which he knows and that he works on subjects which will be valuable to him.

The techniques of the course call for thorough mastery, a maximum of learning, and a minimum of instruction. The text is a laboratory manual in which each exercise leads to the next and encourages the student to develop the subject himself without the comparative dullness of studying a perfected subject.

Very little formal instruction is given and the instructors are available for conference and questions. The student works in the class room for a two-hour period three days a week and turns in his results at the end of each of these periods. The instructors look over the work before the next meeting and indicate what corrections must be made before the student passes on to the next point. In effect, there is individualized study though it is sometimes possible to get together students who are having the same basic difficulty. The student is also, as a part of the course, expected to write a paper on some aspect of mathematics. This tends to project his interest beyond the limits of the text.

Some students cover much more material than others. The important point is not to "get over" a certain amount of subject matter, but to see how mathematical methods are applicable to some specific types of subject matter and to secure a thorough mastery of what is covered. I know of a number of students whose "set" against mathematics has been entirely changed by this course.

We attempt to make use of the experiences which the student gets in his cooperative work, to make use of the comprehensive examination in the case of majors in the field in securing an adequate review of all the college mathematics and getting it placed in perspective, etc. To summarize our attitude I should say that any innovations we have at Antioch are based upon the following:

1. Extensive examinations, frequently by state or national testing agencies, given at entrance and at logical times throughout the college program so that we may discover just what the situation is.

2. Sectionizing after examining all available evidence and then making the type of presentation fit the needs of the sectionized students.

3. A continual attempt to justify all the material we give on the basis of need rather than of formal treatment. This has resulted in some quite drastic changes in both the technical and cultural courses.

4. An attempt to discover individual interests and needs and to adjust the subject matter to individual cases.

5. The discovery of techniques which will aid in securing thoroughness and mastery.

6. A proper balance between logical and psychological method.

7. The elimination of rote learning.

8. An emphasis upon the coming importance of deductive logic in non-physical science without minimizing its value to physical science.

9. An attempt to give the mathematics major, in his later years, some feeling for the spirit of the pure mathematician and, at the same time a sense of the weakness, as well as the strength, of all proofs based ultimately upon induction.

To conclude, I believe that the proper mathematical training of all real high school and college students not only is not an outworn and useless ritual, but rather the most important single aid which can be given to those who are learning to face the complex problems of life. And I believe that it is up to us to make continual changes in our attitudes and teaching techniques so that we may really convince our students that mathematics has value for them.

PETROLEUM PRODUCTS

A booklet entitled, "Petroleum Products," presenting a list of commonly used oil products, a simplified refinery "flow chart" showing how they are made, and a map of the oil-producing areas of the United States, has been prepared by the American Petroleum Institute.

Two editions are available, the larger being printed in two colors on heavy paper suitable for framing. The smaller is intended for hand use.

The "flow chart," one of the simplest pictorial presentations of complicated refining processes yet made, traces the flow of crude oil from the bottom of the well through all phases of refining. All major steps are shown in the manufacture of motor fuel, kerosene, fuel oils, lubricating oils, gas oil, and asphalt. Included is the "cracking" process.

A copy of the larger edition, suitable for framing, will be sent gratis to teachers of classes interested in industrial subjects, and limited quantities of the smaller edition also will be made available.

NICOTINE POISON FOR INSECTS EFFICIENTLY APPLIED BY NEW DEVICE

Man's insect enemies have a new horror of war awaiting them, in a nicotine vaporizer invented by three scientists of the University of California Citrus Experiment Station here, Dr. Ralph H. Smith, Henry U. Meyer and Charles O. Persing. Instead of applying nicotine sulfate as a spray, in the customary manner, it first atomizes the poison fluid and then applies heat to evaporate it.

The deadly vapor is conducted directly into the foliage of insect-afflicted plants, where it proves to be much more efficient than the nicotine sprays at present in common use. If desired, the heat can be left out, and the nicotine mixture applied in the atomized form.

A SUMMER IN SPAIN

By Helen Turner
Oak Park–River Forest Twp. High School, Oak Park, Illinois

It is presumptuous that I should try to describe Spain to you after one summer there. I am afraid my account of that country will be no more accurate than a description of this country made by a person who could not speak English, who spent only a few weeks here, and who saw only those sections of the country that could be visited by train travel. My Spanish trip had just such limitations. I could not talk to the people except with an interpreter, and could understand only snatches of what they said. Though I traveled the whole length of Spain, I saw for the most part only those sections which could be reached easily, and I hurried through even those.

Spain has been described as a country of contrast. There is contrast between the well-watered coastal strips and the semi-desert of the plateau, between the Catalonian of Barcelona and the Andalusian of Seville, between the wealth of the church and the poverty of the peasant farm districts. We traveled for hours over the high plateau where men and women were harvesting fields of scrawny wheat with shears or sickles or threshing it by driving teams around and round over the hard-packed earth, past diminutive close packed villages—with never a tree or flower—baking under a blazing sun, and entered a city, Burgos perhaps, and into its magnificent cathedral with its priceless treasure of gold and jewels. There is contrast too between the gaiety and friendliness of the promenade at evening or the sidewalk cafes of larger cities and the sadness of the drawn, emaciated faces of the all too numerous beggars and cripples.

Spain is a country still living in the past. True, it is becoming industrialized, but it is only in the larger cities that one finds factories and rapid transportation. In fact, the fascination of many of its smaller cities lies in their medieval appearance, their outdoor markets, their procession of sleepy burros, and their cobbled streets. It is an individualistic country where each town has characteristics of its own. Probably one cause of this individualistic tendency lies in its isolation. It is most effectively cut off from the rest of Europe by the Pyrenees. We entered Spain circling the west end and left by circling the east end. Both times we had the towering mountains on one side and the water of the Bay of Biscay or the Mediterranean on the

other. And then within the country itself there is isolation. Mountain chains and deep river valleys have been a hindrance to transportation for so long that each community has developed independently of its neighbors. John Dos Passos in his book *Rosinante to the Road Again* says, "There are many Spains. Indeed every village hidden in the folds of great barren hills, or shadowed by its massive church in the middle of the upland plains, every fertile huerta on the seacoast is a Spain. Iberia exists and strong Iberian characteristics but Spain as a modern centralized nation is an illusion, a very unfortunate one; for the present atrophy, the desolating ruthlessness of a century of revolution may very well be due in large measure to the artificial impositions of centralized government on a land essentially centrifugal."

In the short time I have I cannot tell you all about this country, but there was one part of my trip which was less hurried, one which escaped the highways and during which I met more of the people. It is of that ramble I am going to tell. During the time when my traveling companions were studying in Madrid, the woman who conducted our party and I traveled through part of the country lying within a radius of two hundred and fifty miles to the north, west, and south of Madrid. We traveled largely on the railroad and bus going third class so our pesetas would take us further and that we might meet the people. We visited on that trip Segovia, El Escorial, Toledo, Avila, Salamanca, and several small villages, Candellario, Bejar, Oropesa and LaGartera. The larger of these towns have much in common. They are redolent of the past. Through their narrow streets have passed processions of merchants, priests, Castillian princes; the cries of battle have echoed from their ancient walls. They occupy strategic sites, usually on a hilltop where a good view of the surrounding plateau could be had. And if the hilltop was not a perfect fortification, the city was surrounded by walls which must have been formidable and remain today in Avila in excellent repair. They were thriving cities in the eleventh century, but following the conquest of Granada, they were deserted by the ruling class and so remain today with the same appearance.

We visited first Toledo. It has been described as "more Spanish than Spain." Perhaps that is not quite true, but it is so steeped in the history of Castile that one can easily understand why it is Spain in epitome. I shall always regret that we

had so little time there. I feel that I missed too much, that I scraped only the surface. We followed the usual round of cathedrals, churches, and markets, avoiding the ever-present guides and beggars and getting only a superficial view of the city. One place, however, I did enjoy. It was the home of El Greco, and it is a jewel of Spanish architecture with its open court and fountain. The kitchen is especially charming. A tiny iron grate on the floor at one end is covered by a hood to draw off smoke and smell. On either side of this stove are built in tile benches and tables. And we say that hoods and breakfast nooks are modern! The kitchen opens on a delightful garden somewhat dry in the summer. Later in the day we walked past the house once occupied by Cervantes, under the old moorish gates of the Puerta del Sol, across the Roman brige spanning the Tagus, past an old feudal castle and on to the train. What a wealth of story and romance is in this ancient town!

If one is upset or irritated by delay and procrastination, let him not try to travel in Spain. Our trip from Toledo to Segovia was typical of the difficulties of transportation. We had worked out our itinerary in Madrid with the help of the Patronato Nacional del Turismo, a sort of combined "Ask-Mr.-Foster" and Chamber of Commerce. We were expecting to leave Toledo at 7 A.M. and were trying to arrange an early breakfast at the hotel. The clerk told us it would be impossible to get breakfast at that hour but suggested that we take an eight o'clock train. We were surprised to hear of such a train since it was not scheduled on the regular time-table, but we did finally discover one which went to Aranjuez where we could change for a Madrid train; so we decided to take it. The ticket agent sold us a ticket straight through to Madrid with no mention of the necessary transfer. The gateman who punched our ticket told us to make a transfer at the next stop (not Aranjuez). A bit confused we boarded the train. The conducter told us that he would make inquiry at the next stop to see if the next train was on time. He later delegated that job to a hotel drummer who dashed into our compartment as our train stopped, admonishing us to "Sit tranquil," he would find out. So we sat tranquil till he returned to tell us that the train was two hours late and to advise us to go on to Aranjuez, as we did. We had to wait forty minutes there but caught the train for Madrid with no more mishaps. Upon reaching Madrid we transferred to the bus depot. At least we transferred to the address given to us by the Patronato

Nacional del Turismo, but the depot had moved. In fact it had been moved three months earlier to another section of the city. So we had to cross the city again, but finally caught the bus for Segovia.

Segovia to me is the most interesting city of all, dominated as it is by the old Roman aqueduct, the Devil's Bridge. The city is built on a long narrow hill at one end of which is the famous Gothic palace where Ferdinand and Isabella were married, and at the other the aqueduct. For hours I pushed my tired feet over the rough, cobbled streets, past old houses, along narrow winding lanes, and past walled gardens with only the treetops and vines suggesting their cool shade. And always I wandered back to the aqueduct with the busy market at its feet, and the life of the town passing back and forth beneath it.

Reluctantly we left Segovia for Salamanca. We were traveling third class, may first experience in the box-like, wooden, springless cars, but it is one of my pleasantest recollections. It was lunch time and we had all provided ourselves with train lunches. Ours consisted of big rolls of dry bread, cold omelets, pork chops, cheese, and fruit. Each item except the bread was wrapped in a piece of white wrapping paper, and all of it was packed in a bag. It was like a grab-bag. You put your hand in and wondered what you would pull out. Directly facing us in the compartment were three men—an undertaker, a lawyer, and a bull-fighter. Food and my big pocket-knife dispensed with the necessity of introductions, and by the time we had reached our transfer city, Medina del Campo, we were all in animated conversation. They were most insistent that we go on to Leon where the bull fighter was to take part in an exhibition in a few days. He promised to dedicate a bull to us. When we left they seemed most disappointed and carried our bags in a gallant fashion, though they had to turn and run in a way which must have injured their dignity as the train started rather abruptly.

In Salamanca we stopped at the Terminus Hotel, which wasn't the terminus of anything, and where we were amazed to find our names registered as Marion and Helen. They evidently thought we used the names of both parents as they do and that our official name would not be the last but the next to the last. In Salamanca, noted for its university where Columbus went for help, we were introduced to another Spanish characteristic—courtesy. We were walking through the cloisters of the Univer-

sity, when a gentleman stopped and started to chat. During the course of the conversation it developed that a friend of his had been one of Mrs. Hay's teachers. That was sufficient reason, it seems, for his feeling that it was his duty and his pleasure to show us the city. He took us to all points of interest and beauty, and if we as much as asked about any building, he showed it to us. I hope he was not as tired as we were when the day was over. When he was satisfied that we had not missed anything, he asked us to his home for tea. I wonder how many of us would spare a whole day piloting a foreigner over our city because we knew one of his former teachers.

The small villages, so seldom visited by the tourist, are lovely. We went first to Candelario high up in the Gredos mountains. To reach it we traveled by train to Bejar where, with the assistance of most of our fellow-passengers, we climbed into the back seat of a mail Ford along with a motely collection of tires, tools, and groceries. The Ford took us up over a narrow, rutty, winding road to our destination. We walked through its rough streets where the people still dress in native peasant costume, and where they asked us if we were the same women who had been there two years before. There was snow on the mountain side a short way off. It was so cool and clean and with plenty of water it seemed very unlike the plateau we had left such a short time before.

The other pueblos we visited were LaGartera, noted for its embroidery and its native costumes, and Oropesa. We spent one night in Oropesa and it was with same misgiving that I approached it, driving over the hot dusty plateau in the blazing sun. It was so small, so far away, so hot, and one wondered what kind of water supply it might have, but it turned out to be delightful. We had a hotel room in a remodeled manor house which had been built within the walls of an old fortress castle. The hotel was very clean and comfortable and modern in every respect except appearance. Its thick walls made it cool inside in spite of the heat. The next morning, Sunday, we walked down into the Plaza Mayor (if such it may be called) and sat down to rest in the shade. A queer funeral procession passed up the street and into the churchyard, where the bells tolled an incessant, sorrowful strain. Two little girls dressed like angels next passed, one with her wings upside down. Then we heard faintly the sound of a fiddle and shortly two gypsies appeared around the corner. The man with the fid-

dle was blind; the woman carried a tambourine. They stopped near us and started to play, and the woman to sing. Her song she improvised as she went along. She described us—how we were dressed, how we looked, and what we were doing, much to the amusement of the crowd which had gathered from nowhere in the true Spanish fashion.

One or two more incidents may tell a bit more of the Spaniard's character. Friendly, courteous, procrastinating, hospitable, he is not always polite as measured by our standards. We became accustomed to being stared at and talked to as we walked along the streets, and if the sidewalk was narrow, as it often was, the Spanish men were always able to push us off into the street without seeming to do so. Perhaps "ladies" in Spain do not walk on the street during the day.

The Spaniard has a certain naïveté or artlessness which is perhaps best illustrated by a story. We were walking along one of the better residential streets of Madrid, and Madrid is a modern and beautiful city, when we were annoyed by the smell of a stable. We were surprised to find behind the glass of a store window a number of cattle. The next day we recounted the incident to a professor, who assured us that we must be mistaken. It was forbidden by law to have cattle in such a place, and therefore, if we thought we saw them, we must not believe our eyes. They simply were not there because it was forbidden.

I do not have time to describe for you the rest of Spain, but I hope that some day you will be able to see it for yourself.

A CORRECTION CONCERNING i^n

By L. R. Posey
Southern University, Scotlandville, La.

Professor D. H. Richert misunderstood and hence put the wrong interpretation on the conclusion of my article which appeared in the November issue of School Science and Mathematics in 1934. The formulas are not to be memorized as such. They simply state in symbolic language the rules developed.

Professor Richert's article appears in the February issue of School Science and Mathematics in 1935. His table is good but it is similar to that found in Wells' College Algebra page 198. My rule eliminates the use of any table. All you need to remember is that odd powers of i give imaginary results when the power is decreased by one and divided by two and that even powers of i give real results when the power is divided by two. See the November issue of School Science and Mathematics 1934 for details.

PROGRAM: THE STORY OF RADIO

By F. Joseph Lorz
Monticello Junior High School, Cleveland Heights, Ohio

The presentation here described is an adaptation of a radio program by the National Broadcasting Company, May 10, 10, 1932.[1] It is a dramatization, also, in the nature of a radio broadcast, comprising five parts or scenes as follows:

Dialogue: The electromagnetic theory of Maxwell
The classic demonstration of Hertz
The conception of wireless telegraphy by Marconi
The historic first trans-atlantic message
A rescue at sea[2]

The continuity is enhanced with electrical and sound effects, the former being reproductions of original experiments. The parts are unified by an "announcer" who speaks between them reviewing the past scene and articulating it with the one to follow. This permits time for changes of stage sets. The announcer speaks through a public address system, or, lacking this, from a concealed position, through a megaphone behind a home radio set placed at the side of the stage. In either case, with the exercise of some ingenuity the announcements can be made to simulate a broadcast program.

The writer has obtained gratifying results with a cast chosen from classes, and with apparatus from the equipment of the science department, the hook-ups of which were executed by students. A small orchestral ensemble concealed in the wings behind the announcer furnished incidental music for him and assisted with sound effects. The running time for the whole is forty minutes. The stage sets, costumes, and properties are few and simple.

Thus, the presentation is radio—in subject, source, and treatment.

THE STORY OF RADIO

(*Theme music, "March Militaire" or other*)

Announcer: Good-afternoon, everybody. The program for

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[1] "This dramatization is the property of National Broadcasting Company and is reprinted with special permission. Performance for high school or other non-profit programs may be made without further permission."

[2] This part is dramatic rather than pedagogical. Although it heightens the effect, it might be omitted without sacrifice to unity or completeness when time is a consideration.

this afternoon is offered by the . . . grade science classes. Our story is a history of radio from its beginnings to the present day. The preparation of this program has kept pace with the work on radio done in class. It is an adaptation of a broadcast by the National Broadcasting Company on May 10, 1932, and is presented with their permission.

(*Theme Fade Up*)

Let us take you to London in the year 1873—one year before the birth of the great Italian inventor, Guglielmo Marconi. Let us join two young Englishmen on the corner of a quiet street of this great city, and listen. . . .

PART I. A STREET IN LONDON, 1875

GEORGE: (*Oxford accent*) I say, Geoffrey, here comes that mad Scotchman, Maxwell.

GEOFFREY: Maxwell? Who's he?

GEORGE: Oh, haven't you heard? Well—it's quite a joke. He's that crack-brained mathematician who has been writing books on electro-magnetism.

GEOFFREY: Oh, yes, I have heard of the fellow. Do you know him?

GEORGE: Well, enough to speak to him. Let's ask him about his theory, shall we? It's quite interesting, although of course, utterly impossible.

GEOFFREY: Just what is this theory of his?

GEORGE: He believes that there is in the air a mysterious something, which he calls "ether." It isn't oxygen, or nitrogen, or carbon dioxide, or any of the other known elements—it's something else again.

GEOFFREY: But what is it?

GEORGE: I don't know. Here's Maxwell, Let's ask him. (*Pause*) Good afternoon, Mr. Maxwell.

MAXWELL: (*Slight Scotch accent; book under arm*) Good afternoon, young gentlemen.

GEORGE: I say, Mr. Maxwell, my friend and I were just discussing your new book on Electricity and Magnetism. Won't you give us a clearer idea?

MAXWELL: It is very difficult to explain in words just what the theory means. I have arrived at my conclusions purely through mathematics. However, the theory goes as far back as the ancient Greeks, who spoke of an invisible substance in the air which they called "Aether."

GEORGE: So the Greeks had a word for it, did they?

MAXWELL: Yes. Since then, Huygens has used aether to explain the propagation of light. D'Ahlembert added knowledge to the subject with his mathematical law of wave radiation. Faraday added with his laws of electro-magnetic induction. Now, I merely bind together the work of these different scientists, when, through mathematical formula, I predict that this ether does exist as a wave through space; that this substance is capable of conducting electrical impulses through the air without the aid of wires; and that electrical impulses, discharged into the air, will travel in waves through all of space. In short, the light wave is by nature electro-magnetic.

GEORGE: But Mr. Maxwell—wouldn't that predict the possibility of conducting electrical energy through the air without wires?

MAXWELL: Yes, it does predict that—if electrical impulses strong enough can be discharged, and apparatus sensitive enough can be created with which to intercept them. However, that line of investigation is not my particular field. I am interested only in the theoretical laws of nature. The practical development I leave to other men.

(*Music and Curtain*)

ANNOUNCER: And so—quietly, almost prosaically, it may be said that the first step in radio development was taken. Most of the people who lived in his day never heard of the Scotch mathematician, James Clerk Maxwell. But his theory of electromagnetism and its relation to wave radiation was laid down as a challenge to the entire scientific world.

Maxwell had never seen ether—he had never been in a physical way, able to prove, that electrical impulses could be radiated through space. His work was like that of an astronomer who, through mathematical calculation, predicts the existence of an invisible star. But once the theory was set up, scientists all over the world went to work with feverish haste to see if it could be proved by a physical demonstration.

One of them, fourteen years later, was successful. Let us take you now to the laboratory of Heinrich Hertz, a brilliant young professor of physics at Bonn University, in Germany. The year is 1887—nine years before the epoch-making discovery of Marconi. With Hertz in his laboratory is a young assistant. Listen, here they are, and they are speaking.

PART II. LECTURE HALL IN A GERMAN UNIVERSITY. 1890

HANS: They will be here any moment, Herr Doktor.

HERTZ: Very well, my son. Let them come. I think I shall be able to show them something which will open their eyes. Nicht wahr?

HANS: What is it they will see? I have tried and tried to understand, and yet I cannot.

HERTZ: You are over young, my son, to understand much of what we have been doing. Yet you have been faithful. And now I shall try to make it clear to you. Fourteen years ago, a man named James Clerk Maxwell predicted, through mathematical calculation, that there is in the air something which he calls "ether," which will conduct electricity without wires. Since that time, scientists the world over have been attempting to make a physical demonstration of that fact, to prove the theory. I believe that at last I have accomplished that.

HANS: Then that is the purpose of these devices we have constructed, Herr Doktor?

HERTZ: Exactly. Today I shall prove that electrical energy may be radiated through space, and intercepted at a distant point. That is why, on one side of the room, I have an open spark gap, operated by a switch. On the other side, as you see, is simply an open metal ring, suspended by a wire. Now, when I discharge a spark into the air, from this side of the room, if it sparks in the gap of the ring on the other side, I have proved that electricity does travel unaided through space—and thus I confirm the Maxwell theory.

HANS: But you have already done this, many times. I have seen you do it. The theory must be proved already.

HERTZ: How little you know of the world, boy. The theory is not proved until men have seen it proved. And that is why I have invited this group of scientists here today.

HANS: I hope all goes well, Doktor.

HERTZ: So do I. For if it does, a great scientific fact has been established, and we have thrown open who knows how wide a view into an unknown field of human knowledge.

(*Knock on door*)

HERTZ: (*Continuing*) But we have no more time for talk. That must be the men I am expecting, Hans. Go to the door.

HANS: (*Fading*) Very well, Doktor.

HERTZ: (*To Himself*) Is everything ready? It must be ready. I must not fail.

(*Voices of gentlemen entering room. Fading up*)

HANS: Here are the gentlemen to see you, Doktor.

HERTZ: Guten Tag! Herr Doktor Schumann, Herr Doktor Mueller, gentlemen! Meine Herrn, I have asked you here today to watch a very simple experiment pregnant with meaning. If you will find chairs I shall explain briefly what I shall attempt to do. (*Confusion of guests finding chairs*) Gentlemen, you will see that I have here a very simple apparatus. At this end of the room, just an ordinary electric spark gap. At the other end of the room, a simple metal ring, with a gap left in it. Now, if I can produce a spark at this spark gap which will pass through the room and reach the metal ring, what have I accomplished?

VOICE: Why . . . Why, if you do that you shall have proved Maxwell's theory of electro-magnetic radiation.

HERTZ: Exactly. Gentlemen, never before in all history has this theory been proved by a physical demonstration. It is my purpose to show that ether does exist, and that it will conduct electrical energy. You understand that, gentlemen?

VOICE: We understand, Herr Doktor, but we shall have to see to believe.

HERTZ: Very well, watch. (*Pause*) Hans, throw the switch. (*Crackle of electricity*) (*Excitedly*) You see, gentlemen? You see?

VOICE: Doctor, you've done it!

VOICE: Wunderbar!

1ST VOICE: You have proved the theory.

VOICE: Repeat it please, Herr Doktor.

HERTZ: (*Repeats demonstration*) Gentlemen, you will agree, I think, that the experiment has been a success. As you have seen, there is something in the atmosphere which will conduct electricity through space. That is what I have set out to prove. My work is finished. We have added an important fact to human knowledge. What use future generations will make of this I do not know . . . I bequeath it to them with the hope they will use it well.

(*Music and curtain*)

ANNOUNCER: And so, what Maxwell predicted, Hertz proved. The experiment he had demonstrated was hailed all over the scientific world as a great achievement. It has been proved that electrical energy will travel through space without the use of wires—and that electrical impulses given off at one point, could be intercepted and detected at another.

Thus it may be said that the first wireless set was that of

Hertz—for radio is nothing more than the sending and receiving of electrical impulses. Hertz, however, never dreamed of applying his discovery to a practical use. Neither did the other great scientists who followed him in this new field of scientific experiment. It remained for a twenty-two year old Irish-Italian, Guglielmo Marconi, to see that these experiments were more than interesting scientific phenomena. To him it occurred that these new laws of nature offered mankind another powerful servant, that this strange new knowledge could be applied to a practical usage for the betterment of mankind.

Let us now take you to another laboratory, nine years after the epoch-making demonstration of Hertz. It is late at night. Discouraged, beaten, a twenty-two year old boy sits with his head buried in his hands before a work table. There is a knock on the door. Again, let's look on.

PART II. AMATEUR LABORATORY IN ATTIC

(*Knock on door*)

MARIA: Guglielmo! Guglielmo!

MARCONI: What is it?

MARIA: May I come in?

MARCONI: Yes, come ahead. (*Door opens*)

MARIA: Guglielmo, won't you come to bed now? It is almost ten o'clock.

MARCONI: Maria, please, don't bother me. I have work to do.

MARIA: You are killing yourself, Guglielmo, with your wires and your figures. Won't you go to bed now? In the morning, you will think so much better.

MARCONI: In the morning! Maria, I have felt all evening as if I were on the verge of a great discovery. Time and again I have almost seemed to grasp it. There have been moments when the whole thing seemed about to become clear to me. And each time it has slipped away.

MARIA: But Guglielmo, surely . . . .

MARCONI: It is there, and yet it isn't. I cannot go to bed until I have fought this thing through.

MARIA: What good will it do if you think it out?

MARCONI: What good?

MARIA: Yes, what good?

MARCONI: If Hertz and the others have discovered a mysterious force, so far it is purely a scientific experiment. How to chain that force, how to make it a practical servant of man-

kind, that is my problem. And it is that problem I must solve.

MARIA: But what could you do with it? What good would it do you?

MARCONI: Crookes has already seen the possibility of using this force as a means for communication. Don't you see what that would mean?

MARIA: But we already have the telegraph.

MARCONI: *What?*

MARIA: I say, we already have the telegraph.

MARCONI: (*Very excited*) Maria, you've got it! *We've* got it. Oh, why didn't I think of that before? The telegraph, of course.

MARIA: Guglielmo, have you gone crazy?

MARCONI: Crazy? No, I must have been crazy all this time.

MARIA: But what. . . .

MARCONI: Don't you see? That's all I needed. The telegraph.

MARIA: I still don't see.

MARCONI: It's perfectly simple, now that I've thought of it. Look Maria! You see this switch?

MARIA: Yes.

MARCONI: When I throw it this way, what happens?

(*Sound Effect. Spark*)

MARIA: I don't know.

MARCONI: Simply this. The spark from this spark gap leaps into the air, and is received in a distant point. That's what Hertz did. But I'm going to go a step farther. I'm going to attach a Morse telegraph sender to this switch and operate through it, and then, if I attach a receiver to my distant detector, what happens then?

MARIA: Well, what?

MARCONI: (*With increasing excitement*) The impulses I create with my telegraph key will be received as they are sent, by my telegraph receiver. In other words, it is telegraphy without wires. Don't you see, Maria, its *wireless telegraphy*!

(*Music and curtain*)

ANNOUNCER: And so, Marconi, the inventor, completed the work which had been started by D'Ahlembert, Faraday, Maxwell, Hertz, Branly, Popoff, and many others. Wireless telegraphy was at last a fact. Very crude in its first stages, Marconi worked out refinements and improvements in his equipment. In 1897 Marconi was signalling nine or ten miles. He was aided in the development of his idea by the discovery of tuning, by Sir Oliver Lodge. Gradually the distances over which radio

impulses could be sent and received were increased. In 1898 Marconi had established communication across the English channel, and radio had also been used to report international yacht races between Sandy Hook and the office of the New York *Herald*. Both were considered marvellous exploits at the time. The principal companies equipped their vessels with Marconi wireless sets and many a ship in dire distress was saved by their means.

Then came the supreme triumph of Marconi's career. He conceived the idea of broadcasting across the Atlantic. It was looked on by the people of that time as an absolute impossibility. Yet, let's join the young inventor on the wind-swept shores of Newfoundland, facing hardship and disaster as he struggled to realize the dream of a lifetime.

Part IV: Cabin in Newfoundland

(*Storm Effect: Wind, etc.*)

Marconi: What time is it, Jackson?

Jackson: Two-thirty, sir.

Marconi: And the aerials?

Jackson: They won't hold up if this wind gets much stronger, sir. Already they're bending like rushes in a storm.

Marconi: They've got to hold up! (*Points to clock*) The signal will be sent from England in half an hour. Oh, why did this storm have to come just now?

Jackson: Do we have to do it today, sir?

Marconi: Of course it must be today. Fleming is at the key in England now, ready to make the attempt. If something happens, if those aerials go down, it will mean months of delay. (*Crash off*) Dios mio . . . what was . . . was that?

Jackson: Its happened, sir. They're down.

Marconi: The aerials?

Jackson: Yes sir.

Marconi: Then its over. We're beaten. (*Pause*) No, by heaven, we're not!

Jackson: But what can we do?

Marconi: We'll use a kite for an aerial.

Jackson: (*Incredulous*) A kite?

Marconi: Yes, a kite. I thought of it the other day, and discovered the idea was impracticable. But it might work. It's our only chance.

Jackson: Where will we get a kite?

MARCONI: I've got one ready. It's not much of a chance, but come on. (*Door opens and closes: wind effects up: Man shouting*)

PHILLIPS: Mr. Marconi!

MARCONI: All right, Phillips, what is it?

PHILLIPS: I'm sorry, sir, but the aerials. We did all we could.

MARCONI: Never mind that now. We've only a few minutes. Cut loose the wire from the aerials. We're going to send it up with this kite.

PHILLIPS: Mr. Marconi, is this the time for children's toys?

MARCONI: It's a time for desperate measures. Get me that wire.

PHILLIPS: It's already cut loose, sir. Just a second. (*Fading*) (*Slight pause*)(*Coming up*) Here it is.

MARCONI: Good. Jackson!

JACKSON: Yes, sir!

MARCONI: Can you fly a kite?

JACKSON: I think so, sir.

MARCONI: Then fly this one. If you can get it up, we'll have an aerial!

(*Jackson and Phillips put up large kite visible to audience through open door back stage*)

JACKSON: You hold the kite while I let out some string, and then I'll start running with it.

MARCONI: All right. Hurry.

JACKSON: (*Fading*) Here I go. . . .

MARCONI: If we can only get it up! Feed that wire out carefully, Phillips.

PHILLIPS: Yes sir.

MARCONI: It's catching! It's going up!

PHILLIPS: (*Calling*) Good work, Jackson.

MARCONI: It's up! We have an aerial! What time is it, Phillips?

PHILLIPS: One minute to three.

MARCONI: Now, we'll see what we shall see. Give me the headphones.

JACKSON: Yes, sir. Here they are.

MARCONI: Is the current on? Everything set?

JACKSON: Yes sir.

MARCONI: Silence. (*There are a few seconds of silence, punctuated only by the howling of the wind. Then very faintly is heard the telegraph letter, spark gap "S".*)

MARCONI: I think . . . (*Pause: several more "S's"*) (*Excitedly*) Jackson!

JACKSON: Yes sir?

MARCONI: Jackson, get the headphones.

JACKSON: All right.

MARCONI: Listen! What do you hear?

(*Pause during which signalling is heard*)

JACKSON: I hear it sir! We've done it! That's the signal.

MARCONI: I was afraid to trust my own ears! Jackson, those signals were sent two thousand miles across the ocean! Jackson, we've spanned the Atlantic!

(*Music and curtain*)

ANNOUNCER: In scientific circles, Marconi's triumph was complete. He had spanned the Atlantic. He had proved the efficacy of radio for long distance communication. But even as late as 1911, a great many people still looked on radio as a worthless, newfangled invention. It is true, that in some instances, radio had proved useful. But the public was skeptical, until the morning of the twenty-third of January, 1911—when all the world awoke to read the story of one of the most thrilling sea-rescues ever attempted.

Let us take you on board the White Star Liner, *Republic*, on the night of January 22, 1911. A terrible storm is raging. A heavy fog hangs over the face of the sea. On the bridge of the Republic, Captain Sealby is anxiously charting his course, twenty-six miles off Nantucket, Massachusetts . . . with him is his first mate, and they are talking. Here they are.

(*Fog horn intermittently*)

PART V: BRIDGE OF AN OCEAN LINER

MATE: Dirty weather, Captain Sealby!

CAPTAIN: (*Englishman*) Extremely dirty, Mr. Stevenson. However, I should feel safe if it weren't for this accursed fog! (*Fog whistle blows off*) What was that, Mr. Stevenson?

MATE: What, sir?

CAPTAIN: I thought I heard a fog horn in the distance.

MATE: I heard nothing, sir. Probably some trick of the wind.

CAPTAIN: Yes, probably. Wait a minute. I'm going to get the radio room and find out. (*Into speaking tube*)Radio room!

BINNS: (*Through tube: get metallic, telephonic effect*) Radio room, sir! Binns speaking.

CAPTAIN: Any other ships reported in these waters?

BINNS: No, sir.

CAPTAIN: Very good. (*To Stephenson*) Radio says there are no ships hereabouts. Although whether its wise to trust that new-fangled toy is another question.

MATE: Don't you believe in radio, sir?

CAPTAIN: Oh, it's all right. But as for me, I'd rather trust in good seamanship. (*Fog whistle closer*) Wait a minute. I did hear something that time.

MATE: So did I! Off our starboard bow.

CAPTAIN: Look! Stephenson, look!

MATE: A ship! Coming head on!

CAPTAIN: Good Grief, it's a collision! (*Into tube*) Engine Room! Engine Room!

VOICE: (*Through tube*) Engine Room!

CAPTAIN: Stop that engine! Then give her full speed astern!

MATE: It's too late, sir . . . we're . . . (*Crash*) By George, we've hit!

(*Crowd noises in panic*)

CAPTAIN: We're . . . Sound the general alarm, Mr. Stephenson.

STEPHENSON: Aye, aye, sir! (*Bells begin to ring: shouts of "all hands on deck"*)

CAPTAIN: How bad are we hurt, Stephenson?

STEPHENSON: It looks from here as if the whole bow is smashed in, sir. We won't be able to stay up an hour in this sea!

CAPTAIN: The engines have stopped. (*into tubes*) Engine room!

VOICE: Engine room!

CAPTAIN: What's happened to the engines?

VOICE: Hold's filling rapidly with water, sir. We've had to abandon our posts.

CAPTAIN: Oh, we're done for! There's no help for miles—and no way to get it. Mr. Stephenson, man the life-boats.

STEPHENSON: In this sea? Man, you're crazy.

CAPTAIN: What else can we do?

MATE: Captain, have you forgotten? We still have the wireless.

CAPTAIN: What good can it do?

MATE: It might bring help.

CAPTAIN: We'll have to try it—although . . . (*into tube*) Wireless Room!

BINNS: Yes sir.

CAPTAIN: Send out the following message to all ships: "Steamer *Republic* in Distress and Sinking! Latitude 40 degrees, seventeen minutes; Longitude seventy degrees, twenty-six minutes." And give 'em the P.D.Q. as long as you can stay at your post.

BINNS: Very good, sir.

(*Sparkling of spark gap heard*)

SEALBY: Good grief! Nineteen hundred lives at stake, and only a few strands of wire between them and death!

(*Music and curtain*)

ANNOUNCER: For over an hour, Radio Operator John R. Binns stayed at his post in the sinking ship! Into the stormy air went those little signals which meant life and death! Alone on the high seas—waves breaking over the battered ship . . . no chance for safety . . . unless . . .

But the signals were heard! Two nearby steamers, and two revenue cutters picked up the pleas for help. It arrived just in time! Just before the battered vessel sank under the waves, its passengers were removed. Only six people, who were injured in the original crash, lost their lives. The crew and passengers of the steamer which had collided with the *Republic*—the steamship *Florida*, were saved. It was a convincing triumph for radio! Never again has its practical efficiency ever been doubted!

(*Music—few measures*)

ANNOUNCER: The remainder of the thrilling story of radio we have no time to tell. Much of it is already familiar to you. After Marconi came De Forest, who perfected the vacuum tube, and many others, building on his work just as he had builded upon Maxwell, Branley, and Hertz. The wireless telephone came into being. Broadcasting was inaugurated from studio to home, and with the perfection of short wave reception, between nations. The whole magic mushroom of radio grew and unfolded, into the marvellous servant of mankind it is today.

(*Music—few measures*)

So we bring to a close this program, dedicated to a great application of science. Think of the effort expended in its development when you tune in tonight.

This program has come to you from room No. . . . Your announcer is . . . . Good afternoon.

(*Music*)

ELECTRICAL EFFECTS

Although the demonstration of Hertz (Part II) may be performed satisfactorily in the class-room, in an auditorium the range of visibility would

be limited. Accordingly, it must be "faked," the spark in the receiving ring being a momentarily illuminated Geisler tube across the gap.

This ring is made of a rigid supporting wire (see figure) three or four feet long bent into an incomplete circle with a Geisler tube completing the circle. A wire coat-hanger serves admirably. The whole is suspended at a point opposite the tube by wires coming from the secondary of an induction coil, one of the wires going around each side of the ring to the terminal of the tube. The ring, excepting, of course, the Geisler tube, is covered with white rubber tubing or wound with adhesive tape.

The apparatus producing the spark on the lecture table consists of a small induction coil, battery, and key. The Geisler tube is illuminated in the same way but at a distance and with a separate hook-up. Both keys are operated simultaneously. The wires from the induction coil across the stage to the ring which is hung on the wall near the center of the stage are necessarily concealed.

The spark in Parts III, IV, V may be produced by use of an ordinary spark or induction coil, spark gap, current source and key.

GREAT DOME OF TEXAS OBSERVATORY NOW COMPLETE

The great dome of the 82-inch mirror reflecting telescope in the McDonald Observatory of the University of Texas is completed, Dr. Otto Struve, director of Yerkes Observatory of the University of Chicago, recently returned from Mt. Locke in the Davis Mountains of Texas where the observatory is located. Under terms of the cooperative agreement between the Universities of Texas and Chicago, the former institution is to provide the instruments and buildings for McDonald Observatory while Chicago University is to provide the astronomical staff with Dr. Struve as director.

The 82-inch mirror is now being ground in Cleveland and will be installed by the end of 1935. Observations now being made with a 12-inch refracting telescope on Mt. Locke indicate that astronomical "good seeing" is even better than was anticipated when the site was picked.

MATHEMATICS FOR GRADES SEVEN, EIGHT, AND NINE

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Traditionally the mathematical curriculum offered instruction in arithmetic in grades seven and eight and in algebra in grade nine. Mensurational geometry entered in the form of applications of arithmetic. During the last thirty years many leaders in the field of mathematics and many other educators have raised serious questions in regard to these mathematical offerings. Changes and readjustments have been characteristic of this period, and this applies to education as much as to other fields. It seems plausible that mathematics cannot stay unchanged in such changing times. Materials which formerly were regarded as having great value have in time come to be considered as of little importance or even as detrimental to the subject. Indeed, recently many of the values claimed for mathematics have been questioned and there has been a growing demand for reduction of the time allotted to the subject to make room for other studies.

Unfortunately, these attacks on mathematics have not been altogether groundless. Several investigations have brought to light a great deal of damaging evidence which cannot be overlooked. Thus, it has been shown that only pupils of average mentality, or higher, may reasonably be expected to be successful in high school algebra and geometry in the form in which these subjects are usually presented. Furthermore, it has been shown that the pupils who received passing grades do not retain enough mathematical knowledge to justify the time and effort spent in the study of these subjects. Hence, it is held that high school mathematics is no longer suitable for a large percentage of pupils unless substantial reforms are introduced. Indeed, often the demand is made to abolish all mathematical requirements for graduation.

In striking contrast to this aggressive attitude against mathematics is the indifference to criticism which many teachers of mathematics have adopted. Convinced that mathematics is too important in life to be permanently discarded they show no interest in any far-reaching changes which are undertaken to remove the causes for criticisms.

The majority of teachers does not agree with either of the

two extreme positions. They do not underrate the great values that may be derived from the study of mathematics, nor do they overlook the seriousness of the criticisms. They are willing to try out improvements which give promise to make the study of algebra and geometry more profitable to the pupil and to give him a better preparation for the use of mathematics in other school subjects, the later college courses, and the affairs of everyday life.

Far-reaching changes in a subject as traditional as mathematics cannot be expected to come overnight. However, even a superficial examination of courses of study and textbooks on algebra and geometry gives ample evidence that some very desirable improvements are being made. The teaching process is made more effective, materials are better distributed, and unimportant and obsolete subject matter is being eliminated. More attention is paid to the development of understandings of mathematical concepts and laws. Experiences are more varied. Abstract ideas are presented in concrete settings. Many textbooks devote an entire chapter to the problem of introducing the subject and of preparing the pupil carefully for the work which is to follow.

For years the leaders in the field of mathematics have recommended a redistribution of mathematical subject matter in the hope of solving thereby many of the difficulties of pupils and teachers. In the senior high school courses this has been an exceedingly difficult problem. The junior high school movement, however, has contributed much to simplify the problem. For it is largely a movement of reorganization of the curriculum of grades seven to nine. High school courses in mathematics have been overloaded to the point where the work can no longer be done successfully in the allotted time. There is probably no other subject in which the pupils are being driven so hard. Progress is much too rapid for assimilation. The teachers are forced to be more concerned about covering ground than about the attainment of understandings. Mechanical performance and memorization have been substituted for real learning.

If we follow the recommendation of the National Committee on Mathematical Requirements and regard the three grades as a "unit," it will not be difficult to redistribute the subject matter of mathematics. This will relieve the overcrowded high school courses and at the same time it will place certain phases of algebra, geometry, and even trigonometry where they really

belong from the standpoint of learning and of needs of the learner. By moving the simple aspects of algebra and geometry downward into grades seven and eight many junior high schools and also many elementary schools have brought about an articulation of the work of the lower and upper courses. A double purpose has been accomplished. It has been possible to teach in grades seven and eight the arithmetic, geometry, and algebra which people in general should know and at the same time to construct a foundation on which to build courses in algebra and geometry free from the defects which have brought much criticism upon the teachers of mathematics.

The work of the junior high school has been strengthened by utilizing the interrelations which exist between arithmetic, algebra, and geometry. Geometric subject matter is used to clarify the abstract processes of algebra. Algebraic symbols, formulas, and equations are used whenever they simplify the study of geometry.

Furthermore, when secondary mathematics begins with the seventh grade the teachers will find more time throughout the entire secondary school period to pay attention to the arithmetical deficiencies of pupils. This will go far to eliminate the criticism that high school graduates are poorly grounded in arithmetic.

For a number of years the department of mathematics of the University of Chicago High School has been working on a reconstruction of the mathematics courses. The part of this experiment which is concerned with the work of grades seven, eight, and nine will be briefly outlined in this paper

At present all pupils of the University High School are required to study mathematics during three years, beginning with the seventh grade. From the tenth grade on the courses are elective. In the seventh and eighth grades mathematics and science alternate to permit integration within these two fields. Each subject has been allotted four periods a week for one semester. In the ninth grade four periods a week throughout the entire year are set aside for mathematics. Ninth-grade pupils in the University High School are ranked as sophomores.

It is aimed to develop in the three years a high degree of proficiency in the manipulative phases of arithmetic and algebra, an understanding of the basic concepts and principles of algebra and geometry, and ability to solve verbal problems. All pupils are given a diagnostic test in arithmetic at the beginning of each

course, and the teachers assume the task of correcting arithmetical deficiencies of classes and individuals as the work progresses in each grade. A similar responsibility is assumed by the teachers of science.

An experiment is being tried this year with a select group of sophomores. They will finish Algebra I and cover a large part or all of Algebra III. In the junior year, which is the tenth grade, they will probably be able to finish plane and solid geometry and one unit in trigonometry. In the senior year, or the eleventh grade, a course in college mathematics comprising trigonometry, college algebra and analytic geometry will be organized for them.

Mathematics of the Seventh Grade of the University High School

Four periods a week for one semester.

I. *Learning to measure lines. Getting acquainted with a simple algebraic notation. Acquiring proficiency in arithmetical computation.*

The basic subject of Unit I is intuitive geometry. The pupil is taught the use of ruler and compasses in drawing, measuring and adding lines. This activity introduces many opportunities for reviews and practice in the arithmetical processes with integers and common and decimal fractions. Literal numbers and simple linear polynomials are introduced. Substitution and evaluation exercises give further practice with arithmetic. Training is provided in the technique of solving simple problems by arithmetical methods.

References: Seventh-Year Mathematics, Chapter I (Macmillan); *Senior Mathematics,* Book I, §§ 1–7 (University of Chicago Press).

Time allotment: 15 class periods.

II. *Learning the use of the metric system by measuring lines. Working verbal problems in percentage and its applications. Obtaining much practice in arithmetical computation.*

Linear metric units are taught and used. Lines are now measured with the metric ruler and metric squared paper. The pupils work many problems in finding percentages, verbal problems in discount, commission and simple interest. Excellent opportunities for integration of mathematics and the social sciences are offered in this unit.

References: Seventh-Year Mathematics, Chapter II (Macmillan) *Senior Mathematics,* Book I, §§ 8, 9 (University of Chicago Press).

Time allotment: 13 class periods.

III. *Solving problems by arithmetic*

The technique of problem solving has received some attention in units I and II. Unit III summarizes this procedure and extends it further. The problems are related to situations with which pupils of this level come in contact in the home, store and elsewhere. Problems in accounts, bills, interest, discount, commission, and insurance are typical examples. Through these problems the unit presents opportunities for integration of mathematics and the social sciences.

References: Seventh-Year Mathematics, Chapter V (Macmillan).

Time allotment: 10 class periods.

IV. *Using ruler, compasses, squared paper, and protractor to draw and measure angles, and to draw parallel lines.*

The activities of this unit aim to develop understandings of the angle concept and certain relationships between angles, to make clear the meaning of parallel lines; to acquaint the pupil with various methods of drawing parallel lines; and to give practice in the use of the geometric drawing instruments. Algebraic symbolism is introduced in denoting lengths of lines, sizes of angles, and angle relationships. Problems relating to angles offer practice in the use of angular units and in arithmetical computation.

References: Seventh-Year Mathematics, Chapter III (Macmillan).

Time allotment: 10 days.

V. *Drawing circles and designs. Solving problems related to the circumference of the circle.* Practice in drawing with the geometric instruments is continued. Through this work it is aimed to develop an understanding of the circle concept and an appreciation of the frequent uses of the circle in everyday life. The drawing of designs offers opportunities for integration of mathematics and art. Circumference problems are solved by means of the circumference formula, and practice is thus given in the use of algebraic symbols, in arithmetical computations, and in problem solving.

References: Seventh-Year Mathematics, Chapter IV (Macmillan); *Senior Mathematics,* Book I, §§ 56–57 (University of Chicago Press).

Time allotment: 9 class periods.

VI. *Learning to represent number facts graphically.*

The meanings and uses of various kinds of graphs are taught. Practice is given in drawing graphs and interpreting them. The idea of approximate measure leads to approximation of arithmetical numbers. Arithmetical computation receives much attention.

References: Seventh-Year Mathematics, Chapter VI (Macmillan); *Senior Mathematics,* Book I, §§ 36–39 (University of Chicago Press).

Time allotment: 9 class periods.

Mathematics of the Eighth Grade

Four periods a week for one semester.

I. *Solving problems involving lengths of lines, angle relations, perimeters, and circumferences of circles.*

Emphasis throughout this unit is on skill and accuracy in arithmetical computations which arise in problems. Further facts are taught about perimeters, angles, and circles. Ruler and compasses are used to make geometric constructions and designs which provide opportunities for integrating mathematics and art. Latitude and longitude are presented in a simple manner, and mathematics is thus correlated with certain aspects of the science course. Geometric magnitudes and relationships are stated in algebraic symbols and simple formulas.

References: Seventh-Year Mathematics, Chapter IX (Macmillan); *Senior Mathematics,* Book I, §§ 125, 126, 134 (University of Chicago Press).

Time allotment: 9 class periods.

II. *Solving problems involving areas of rectilinear figures and circles.*

Unit II aims to develop further the technique of solving verbal problems and to increase skill in arithmetical computation. Problems are related to measures of the surfaces of the common plane figures. The pupil is made acquainted with many properties of these figures. He acquires a knowledge of the formulas

used to find areas. This introduces him to algebraic expressions of the second degree. He learns to solve simple equations of the forms $ax=b$, and $ax^2=b$.

References: Seventh-Year Mathematics, Chapter VII (Macmillan); *Senior Mathematics,* Book I, §§ 187–190 (University of Chicago Press); *Eighth-Year Mathematics,* §§ 22–30 (Macmillan).

Time allotment: 14 class periods.

III. *Solving problems which involve the process of extracting square roots and which require a knowledge of the Theorem of Pythagoras.*

Problems related to areas of squares and circles and to the Theorem of Pythagoras lead the pupil to learn the meaning of square root and the process of finding square roots of arithmetical numbers. He acquires an understanding of the abbreviated processes of multiplication and division and of the meaning of approximate values of roots. He learns how to find the squares of sums or differences of two terms.

References: Eighth-Year Mathematics, Chapter III (Macmillan); *Senior Mathematics,* Book I, §§ 178–186 (University of Chicago Press).

Time allotment: 16 class periods.

IV. *Solving problems about areas and volumes of solids.*

Emphasis on arithmetical computation is continued. The formulas for finding areas and volumes of solids introduce further algebraic expressions of the second and third degree. The problems aim to increase the pupil's understanding of the algebraic formula and to train him in space imagination.

References: Eighth-Year Mathematics, Chapter IV (Macmillan); *Senior Mathematics,* Book I, §§ 195–99 (University of Chicago Press).

Time allotment: 17 class periods.

V. *Solving practical problems.*

The aim of unit V is to train pupils in arithmetic and in the use of algebraic formulas in solving verbal problems. The problems relate to investments, banking, insurance, taxes, duties and revenue. Many opportunities to correlate mathematics and the social sciences are presented in this unit.

References: Eighth-Year Mathematics, §§ 31–9, 82, 84, 86, 87, 91, 92, 93 (Macmillan).

Time allotment: 10 class periods.

Mathematics of the Ninth Grade

Four periods a week for the entire year.

I. *Solving verbal problems by means of simple equations.*

The pupil learns to express numerical facts in terms of algebraic symbols, to derive equations from verbal problems and then solve the equations by use of mathematical laws. Practice is given in performing simple additions and subtractions of polynomials.

References: Senior Mathematics, Book I, §§ 17–35, 40–54, 58–66 (University of Chicago Press); *Eighth-Year Mathematics,* Chapter IX (Macmillan); *Ninth-Year Mathematics,* §§ 60–69 (Macmillan).

Time allotment: 19 class periods.

II. *Learning to work with positive and negative numbers.*

It is aimed to develop a clear meaning of signed numbers. The laws of signs are then developed and much practice is provided in the use of the laws in simple exercises.

References: Senior Mathematics, Book I (University of Chicago Press); *Eighth-Year Mathematics,* Chapter X (Macmillan); *Ninth-Year Mathematics,* Chapter II (Macmillan).

Time allotment: 13 class periods.

III. *Studying algebraic and geometric relationships between angles.*

The pupil is made acquainted with many relationships between angles, parallel lines, and intersecting lines. He learns to express the relationships algebraically by means of equations and formulas. Much practice is given in solving linear equations, formulas, and verbal problems.

References: Senior Mathematics, Book I, §§ 116–138 (University of Chicago Press); *Eighth-Year Mathematics,* §§ 158–161 (Macmillan).

Time allotment: 13 class periods.

IV. *Solving problems leading to linear equations in one variable.*

This unit summarizes what the pupil has previously learned about solving verbal problems and linear equations. This knowledge is rounded out and extended to develop proficiency in both types of work. The aim is the ability to solve any linear equation in one unknown and integral or fractional coefficients.

References: Senior Mathematics, Book I, Chapter IX (University of Chicago Press); *Ninth-Year Mathematics,* §§ 70–80 (Macmillan).

Time allotment: 15 class periods.

V. *Solving problems leading to equations in two variables.*

Graphical and algebraic methods of solving simultaneous equations are taught. Practice in solving verbal problems is continued.

References: Senior Mathematics, Book I, §§ 225–40 (University of Chicago Press); *Ninth-Year Mathematics,* Chapter V (Macmillan).

Time allotment: 10 class periods.

VI. *Solving problems leading to quadratic equations in one variable.*

Two methods of solving quadratic equations are taught: the graphical method and the method by completing the square. As in the preceding units, emphasis is placed on the technique of solving verbal problems.

References: Senior Mathematics, Book I, Chapter XI (University of Chicago Press); *Ninth-Year Mathematics,* §§ 128–37 (Macmillan).

Time allotment: 8 class periods.

VII. *Attaining proficiency in the fundamental algebraic processes.*

In the foregoing units algebraic processes were introduced and taught as need for them arose. Usually the exercises were simple because no complicated operations occurred in the solutions of problems. The pupil is now prepared to profit greatly by the study of a unit which is entirely devoted to the four fundamental processes. Unit VII reviews, summarizes, and extends his knowledge about the operations with monomials and polynomials.

References: Senior Mathematics, Book I, Chapter XII (University of Chicago Press).

Time allotment: 19 class periods.

VIII. *Attaining proficiency with factoring and fractions.*

Three types of factoring are taught: the polynomials with a factor common to all terms, the difference of two squares, and

the quadratic trinomial including the perfect trinomial square as a special case. Factoring is used in solving quadratic equations. The study of fractions is closely correlated with factoring and covers the four fundamental operations with fractions.

Reference: Senior Mathematics, Book I, Chapters XIII and XIV (University of Chicago Press).

Time allotment: 15 class periods.

IX. *Developing skill in the fundamental constructions of geometry.*

Units I to VIII complete the algebraic work of the ninth grade. The pupil is now being prepared for the study of demonstrative geometry which begins in the tenth grade. Unit IX reviews and completes his knowledge of the fundamental constructions. These constructions are not taught by themselves, but are freely applied to problems in designs and to other constructions. The pupil is expected to become skillful in the use of ruler and compasses.

References: Senior Mathematics, Book I, §§ 114–115 (University of Chicago Press); *Eighth-Year Mathematics,* Chapter I (Macmillan).

Time allotment: 8 class periods.

X. *Solving problems in finding unknown distances.*

This unit is a review of all the geometry previously taught. The work is unified under the problem of finding unknown distances. It is extended to include the principles of congruence and similarity, ratios, proportion, and the tangent ratio of trigonometry. Proportions are solved by means of the multiplication and division axioms. A gradual transition is made from the informal to the demonstrative type of geometry.

References: Senior Mathematics, Book I, §§ 143–57 (University of Chicago Press); *Eighth-Year Mathematics,* Chapter XII (Macmillan).

Time allotment: 12 class periods.

The foregoing program is by no means in its final stage of development. However, it is the outcome of many trials and experimentations. There is much to be said in favor of it. The arguments for it may be briefly summed up as follows:

1. It provides for systematic use and practice in arithmetic during the entire secondary school period.

2. It provides for the immediate mathematical needs of the pupils in everyday life and in other school subjects. At the same time it lays the foundation for the study of mathematics in future courses.

3. It redistributes the content of secondary school mathematics and thereby increases the time needed to attain understandings of the basic mathematical concepts. It makes it possible to remove some of the major criticisms of the traditional courses in algebra and geometry of grades nine and ten.

4. It conforms to the program of the National Committee on Mathematical Requirements for the junior high school which recommended instruction in arithmetic, intuitive geometry, algebra, and some trigonometry.

5. It provides opportunities for the correlation of mathematics, art, and the natural and social sciences.

6. It is so organized as to keep in use skills and processes after they have been taught.

7. It places emphasis on formulas, graphs, problem solving, and functional thinking.

8. It facilitates the transition from intuitive to demonstrative geometry.

9. It is an activity program which leads the pupil to learn by doing.

SCIENCE QUESTIONS

May, 1935

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

Readers are invited to co-operate by proposing questions for discussion or problems for solution.

Examination papers, tests, and interesting scientific happenings are very much desired. Please enclose material in an envelope and mail to Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

GUILD QUESTION RAISERS AND ANSWERERS (GQRA)

Join by sending in a question or an answer. Pupils and classes are eligible. Let your class propose a question or send an answer. Send in your question NOW.

JOIN THE GQRA

PLEASE EXPLAIN

711. ***Proposed by R. T. Harling, Memorial University College, St. Johns, Newfoundland.*** *(Elected to GQRA. No. 68.)*

I should like to propose the following for your "Science Questions." I have sought in vain for an answer in the textbooks.

"When dust settles on the plastered walls and ceiling of a room, it does not do so evenly. After it has accumulated sufficiently, the rafters and laths behind the plaster may be seen clearly worked out in a lighter tone than the remainder. How does the woodwork behind an inch thickness of plaster affect the settling of dust on the surface? Further, if there is a crack in the plaster of a vertical wall, the plaster on the lower side of the crack remains much cleaner than that on the upper side; and all edges where two walls meet also remain markedly free from deposit. What is the reason for these facts?"

FOR THE SAILORS

712. *Proposed by Bernard R. Ptaszkiewicz. Riverside High School, Buffalo, N. Y. (Elected to GQRA No. 69.)*

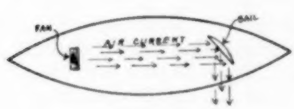
Provided there is no wind or water current acting upon a stationary sailboat, would motion be produced by a fan placed in two positions stated below? and if so, would the motion be straight or circular?

First Condition: The electric fan placed so that it will produce air currents directly into the sail.

Second Condition: The electric fan placed so that it will produce air currents hitting one side of the sail and then sliding off at an angle.

I

II



GOLD

713. *Asked by G. H. Jamison, Kirksville, Mo. (Elected to GQRA No. 82.)*
What is the volume of the U. S. gold dollar?

Also the following questions Nos. 620 and 621, asked in May, 1933. Are the answers now (May, 1935), the same as they were in 1933?

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620. What is the specific gravity of gold?

A hoarder came into the Federal Reserve Bank at Cleveland with certificates calling for $82,000 in gold coin. How much did it weigh?

---

621. "Pop Eye," the sailor, cast his $10,000,000 of gold into a cube to protect it from thieves. How large was the cube?

714. *Proposed by Ernest Bodnar, Riverside H. S., Buffalo, N. Y.* (*Elected to GQRA No. 74.*)

I wish to become a member of your club, the GQRA. I am a student in Mr. Masson's class and I am submitting the following questions:

Suppose a hole six feet in diameter were bored clear through the center of the earth to the other side in China or Australia. If a man fell or jumped into this hole from our end of it, (1) Would he fall clear through to the other end? (2) Would he fall to the center and stop there? (3) Would he fall past the center and then return, pass it oscillating back and forth until he came to rest somewhere? State reasons or proof for the answers given.

---

715. *Proposed by Robert H. Grimes, Riverside H. S., Buffalo, N. Y.* (*Elected to GQRA No. 76.*)

I wish to become a member of the GQRA. I am submitting this question.

We are told that by reducing the air pressure about a boiling liquid, the temperature, at which it boils is lowered. That is water can be made to boil at 100° C, 90° C, 80° C, etc. By reducing the pressure sufficiently, can water be made to boil and freeze at 0° C at the same time?

Other Questions to be used later—proposed by Carl E. Heilman, Paulsboro, N. Y., GQRA No. 55; W. C. Hawthorne, Chicago, Ill., GQRA No. 67; Adrian Struyk, Paterson, N. J., GQRA No. 75; W. S. Leskowitz, Pittsburgh, Pa., GQRA No. 66; Robert F. Ortner, Riverside H. S., GQRA No. 78; Loretta Beltek, Riverside H. S., GQRA No. 79; Leota Knox, Riverside H. S., GQRA No. 80; Ralph J. Eschborn, Riverside H. S., GQRA No. 83.

Solutions have been received from—A. H. Gould, Milwaukee, Wis., GQRA No. 12; Charles W. Trigg, Los Angeles, Cal., GQRA No. 18; Margaret Joseph, Milwaukee, Wis., GQRA No. 27; Maxwell Reade, Brooklyn, N. Y., GQRA No. 48; Charles C. D'Amico, Albion, N. Y., GQRA, No. 49; Carl E. Heilman Paulsboro, N. J., GQRA No. 55; O. B. Rose, Garrett, Ind., GQRA No. 61; Dr. Newton C. Jones, Niagara Falls, N. Y., GQRA No. 70; Douglas Ort, Riverside H. S., Buffalo, N.Y., GQRA No. 71; Edmund W. Mioducki, Riverside H. S., Buffalo, N. Y., GQRA No. 73; Ernest Bodnar, Riverside H. S., Buffalo ,N. Y., GQRA No. 74; Adrian Struyk, Paterson, N. J., GQRA No. 75; John E. Flora, Hoagland, Ind., GQRA No. 77; Rose Kowaloff, Brooklyn, N. Y., GQRA No. 81; Jack Doran, Riverside H. S. Buffalo, N. Y., GQRA No. 84; Charles F. Turner, Cleveland, Ohio, GQRA No. 85.

Gas Meter Problem

700. *Proposed by Allan J. Rosenthal, Senior Physics Class, Brookline High School, Brookline, Mass.* (*GQRA No. 65.*)

A, *B*, *C* and *D* are four gas meters in the same apartment house and on the same gas line. *A* and *B* are in the attic—six stories above the street. *C* and *D* are in the basement. *A* and *C* are kept at an average temperature of 70° F; *B* and *D* at 35° F. The gas is used in each instance to supply fuel for a kitchen range. The gas company's charges are at the rate of one dollar per thousand cubic feet. Which customer gets the most for his money?

Solution by "A Chemist"
Cleveland, Ohio. (*Elected to GQRA No. 85.*)

I have your letter setting forth the example in physics presented to you by Allen J. Rosenthal, Brookline High School, Brookline, Mass. I wonder if the problem is stated correctly in your letter which says that meters *A* and *B* are in the attic and *C* and *D* in the basement and that *A* and *C* are kept at a temperature of 70° F and *B* and *D* at 35° F. This would mean that one attic meter and one basement meter are kept at 70° F, while the other two are kept at 35° F. This does not seem logical to me and I have therefore taken the liberty of assuming that meters *A* and *B* are maintained at 70° F while *C* and *D* are maintained at 35° F.

This is a very simple application of Charles Law which states in effect that under constant pressure the volume of a gas varies directly as its absolute temperature. I presume these students are familiar with absolute temperature but I will repeat here by saying that in problems of this kind comparisons must always be made on an absolute base, whether it is temperature or pressure. We normally use 460° on the absolute scale when dealing with Fahrenheit temperatures and 273° when dealing with Centigrade temperatures. On the absolute scale, a volume of gas decreases 1/460th for every degree decrease in temperature. This gives us, then, the definition of absolute zero which is: At zero degrees absolute, the volume of a gas becomes zero. In the problem, then, meters *A* and *B* have a temperature of 530° absolute and meters *C* and *D* have a temperature of 495° absolute.

There is one factor which has been omitted from the problem but which must be taken into consideration to arrive at the right answer and that is the heating value of the gas and the definition of the "cubic foot." The latter is defined as being that amount of gas which will occupy one cubic foot of space at 60° F, 30.0″ of mercury pressure and saturated with water vapor. The B.T.U. value of the gas is immaterial in this problem but I have assumed 700 BTUs per cubic foot.

We now proceed to find out how many BTUs exist in a cubic foot which is measured at 70° F and in one which is measured at 35° F (we will assume barometric pressure to be the same in all cases, i.e., 30.0″ Hg).

$$\frac{600 \times 520}{530} = 589 \text{ BTUs in a cubic foot of gas measured at } 70° \text{ F.}$$

$$\frac{600 \times 520}{495} = 630 \text{ BTUs in a cubic foot of gas measured at } 35° \text{ F.}$$

Now to answer the question as to which customer gets the most for his money:

Tenants using meters *A* and *B* pay $1.00 for 1000 cubic feet of gas containing 589,000 BTUs.

Tenants using meters *C* and *D* pay $1.00 for 1000 cubic feet of gas containing 630,000 BTUs.

This problem may be termed a catch problem in the sense that gas is almost always metered on the customer's premises without correction to standard cubic feet. In other words, the cubic feet for which the customer pays are the cubic feet measured by his meter under the temperature conditions existing within his meter. This condition is largely self-compensating and the problem discussed here explains why we apply the following reason:

We assume here that the temperatures mentioned were taken during the summer months. During the winter months, the reverse would be true: meters *A* and *B* would be more nearly at an average temperature

of 35° F while mters C and D would be more nearly at an average temperature of 70° F. In this way a pretty close balance is maintained.

A seemingly simple question becomes rather involved in its analysis such as in this problem and I trust that I have made myself sufficiently clear.

AIR PLANE PROBLEM

701. *Proposed by I. N. Warner, (GQRA No. 56) State Teachers College, Platteville, Wis.*

Here is a problem and "formula" from a book we have in our Training School, 8th Grade, (Junior H. S.).

Problem: An air plane makes 110 miles per hour with the wind and 40 miles per hour against the wind. What is the *average* rate of the plane in "miles per hour?"

The book gives the solution: $\dfrac{110+40}{2}=75$ miles. Answer.

Is this answer really the "average rate of the plane?"

Answer by "An Air-craft Engineer," Cleveland, Ohio. (Elected to GQRA, No. 72.)

The answer to Mr. Warner's question relative to the speed of the airplane in his problem is—"Believe it or not"—both he and the textbook are right. The textbook's error is in not differentiating for the benefit of the student and Mr. Warner, between "air speed" or the speed of the plane relative to the air and "ground speed" or the speed of the plane relative to the ground. Performance guarantees of planes are always made on the air speed of the plane since the manufacturer can obviously not be held responsible for the wind which the purchaser may encounter. In flight tests, the measured air speed is determined in the manner given in the textbook while the operator of a plane who wishes to go to a certain point and return in a given time must work out his analysis on a basis of ground speed as Mr. Warner did.

The whole picture can be readily shown by simple mathematical analysis:

$$\text{Let } V_p = \text{Air Speed, miles per hour}$$
$$V_w = \text{Wind Speed, miles per hour}$$
$$\text{Obviously, Ground Speed with the wind} = V_p + V_w = 110 \text{ MPH}$$
$$\text{Ground Speed against the wind} = V_p - V_w = 40 \text{ MPH}$$
$$\text{Adding—}2V_p = 150,\ V_p = 75 \text{ MPH}$$
$$\text{Subtracting2—}V_w = 70,\ V_w = 35 \text{ MPH}$$

Now from the operator's standpoint, given a plane of 75 MPH air speed and an objective D miles away in the direction of the 35 MPH wind, if he wants to find his ground speed on a round trip:

$$\text{Time with wind} = \frac{D}{75+35} = \frac{D}{110}$$
$$\text{Time against wind} = \frac{D}{75-35} = \frac{D}{40}$$
$$\text{Total time} = \frac{D}{110} + \frac{D}{40} = \frac{15D}{440}$$
$$\text{Ground Speed} = \frac{2D\ (440)}{15D} = 58.7 \text{ MPH}$$

FELIX JOHN'S MONKEY PROBLEM

691. *Proposed by Brother Felix John, (GQRA No. 18) La Salle College, Philadelphia, Pa.*

A piece of rope weighs four ounces per foot. It is passed over a pulley and on one end is suspended a weight and the other end a monkey. The whole system is in equilibrium.

The weight of the monkey in pounds is equal to his mother's age in years. The age of the monkey's mother added to the age of the monkey is four years. (1) The monkey's mother is twice as old as the monkey was when (2) the monkey's mother was half as old as the monkey will be when (3) the monkey is three times as old as the monkey's mother was when (4) the monkey's mother was three times as old as the monkey.

The weight of the rope or the weight at the end is half as much again as the difference between the weight and the weight plus the weight of the monkey. How long is the rope?

Answer by Adrian Struyk, (Elected to GQRA, No. 75) Paterson, N. J.

Let $w=$ weight of monkey in lbs.

Then $w=$mother's present age in yrs., and $4-w=$monkey's present age in yrs.

Difference in ages $=w-(4-w)=2w-4$.

This difference is always the same.

Let $a=$monkey's age at time (4).

Then $3a=$mother's age at time (4).

Difference $=3a-a=2a=2w-4$.

Hence $a=w-2=$monkey's age at time (4), and $3w-6$ mother's age at time (4).

Hence $9w-18=$monkey's age at time (3).

Hence $9w/2-9=$mother's age at time (2).

Monkey's age th en is mother's age minus difference in ages

$$=\left(\frac{9}{2}w-9\right)-\left(2w-4\right)=\frac{5}{2}w-5.$$

Hence $5w-10$ is mother's age at time (1), which is now.

Therefore $5w-10=w$, or $4w=10$, so that

$$w=2\tfrac{1}{2}\text{ lbs.}=\text{wt. of monkey.}$$

Difference between (weight) and (weight plus weight of monkey) is weight of monkey.

Weight of rope $=1\frac{1}{2}$ times $2\frac{1}{2}=3\frac{3}{4}$ lbs. $=15/4$ lbs. $=15$ times 4 oz.

Hence the rope is 15 ft. long.

Another solution by Rose Kowaloff (Elected to GQRA No. 81) and Maxwell Reade, (GQRA No. 48), Brooklyn, N. Y.

On this first day of spring we hied ourselves to a cozy table and attempted to solve problem #691. After wrestling with the varied interpretations of the last sentence, we decided to send our hard-earned solution to you. It follows.

Age problem

	Long Ago	Ago	Now	Future
Monkey	y	$5y/2$	$3y$	$9y$
Mother	$3y$	$9y/2$	$5y$	$11y$

but $3y+5y=4$, or $y=\frac{1}{2}$ hence mother is $2\frac{1}{2}$ yrs. old. It then follows that the monk is 40 oz. heavy.

let the rope be N feet long
then $4N=3/2(40)$
$\therefore N=15$ feet.
Our answer is then that the rope is 15 feet long!!
We hope it is at least near the correct result!
Thank you—

TELESCOPE FINDER PROBLEM

682. *Proposed through W. F. Roecker (GQRA, No. 15) Milwaukee, Wis.*

Amateur astronomers sometimes use a finder on their telescopes consisting of a tube about one inch in diameter with a pin-hole in the center of the closed end and with cross-hairs mounted on the open end. When looking at the moon through such a finder its size appears to be considerably smaller than when viewed with the naked eye. Explain.

Answer by Charles C. D'Amico, (GQRA, No. 49)
Albion, N. Y.

Relative to the question proposed through Mr. W. F. Roecker of Milwaukee, as regards why, when looking at the moon through a finder as described in the question, the moon's size appears to be considerably smaller than when viewed with the naked eye, I would answer:

The finder acts as a pin-hole camera (camera obscura). The pinhole, to put it simply, acts as a lens, producing a small, real and inverted image of the moon. Since the moon's distance is large, applying the law of the pinhole camera $\left(\frac{L_1}{L_0}=\frac{D_1}{D_0}\right)$, it is seen that the image is smaller than the object, etc.

PROBLEM DEPARTMENT

Conducted by G. H. Jamison
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink, Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

NOTE. Persons sending in solutions and submitting problems for solution should observe the following instructions

1. Drawings in India ink should be on a separate page from the solutions.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1364. *David Blackwell, Centralia, Ill.*

1376. *Proposed by Norman Anning, University of Michigan.*

Solution bv Dorothy Ingram, Pythagorean Club, Hyde Park (Chicago).

$$\sqrt{x}-\sqrt{y}=-1 \qquad (1)$$
$$4\sqrt{x}=y \qquad (2)$$

$$\sqrt{x}-\sqrt{y}=-1 \qquad (1)$$
$$4\sqrt{x}-y=0 \qquad (2)$$

$$4\sqrt{x}-4\sqrt{y}=-4 \qquad (1)$$
$$4\sqrt{x}-y=0 \qquad (2)$$
$$-4\sqrt{y}+y=-4$$
$$y-4\sqrt{y}+4=0$$
$$(\sqrt{y}-2)(\sqrt{y}-2)=0$$

if $\sqrt{y}-2=0$	if $\sqrt{y}-2=0$
then $\sqrt{y}=2$	then $\sqrt{y}=2$
$\begin{cases} y=4 \\ x=1 \end{cases}$	$\begin{cases} y=4 \\ x=1. \end{cases}$

Solutions were also offered by W. E. Buker, Leetsdale, Pa., Mabel and Maxwell Reade, Brooklyn, Elizabeth Marshall, Niantic, Ill., Margaret Joseph, Milwaukee, Roy MacKay, Portales, N. Mexico, R. A. Miller, University of Miss., Charles C. D'Amico, Albion, N. Y., Hobson M. Ferbe, Wilkes-Barre, Pa., Walter S. Leskowitz, Pillsburg, Kenneth Carlson, Kearney, Nebr. and Harus Miyamoto, Honolulu.

1377. *No solution has been received.*

1378. *Proposed by Charles W. Trigg.*

Prove geometrically that the medians of a tetrahedron meet in a common point which is three-fourths of the length of each median from its vertex. (A median of a terrahedron is a line joining a vertex to the centroid of the opposite face.)

Solved by Aaron Buchman, Buffalo, N. Y.

Given tetrahedron $ABCD$.

Pass a plane through A, D, and E, the midpoint of BC.

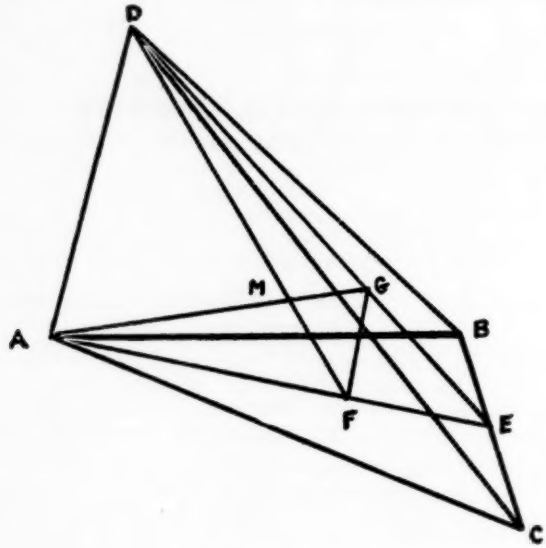
G, the centroid of ΔDBC, divides DE in the ratio 2:1.

F, the centroid of ΔABC, divides AE in the ratio 2:1. Let AG and DF meet at M. From similar triangles it follows that $\dfrac{FM}{MD}=\dfrac{FG}{AD}=\dfrac{EG}{ED}=\dfrac{1}{3}.$

Hence M is three-fourths of distance of DF from D and also $AM=\frac{3}{4}AG$.

Similarly, by passing appropriate planes, we can show that the other medians of tetrahedron $ABCD$, cut DF at the same point M, and are each divided by M in the ratio 3:1.

$\therefore$ **the medians of a tetrahedron** are concurrent at a point which is three-fourths of the length of each median from its vertex.



Solutions were also offered by H. C. Torreyson, Chicago, Chas. C. D'Amico, Albion, N. Y., Mabel Reade, Maxwell Reade and Emmet Pardon, Brooklyn, N. Y., W. E. Buker, Leetsdale, Pa., and Herbert Spiro, Storrs, Connecticut.

1379. *Proposed by William Kent, Spokane, Washington.*

Using only logarithms and doing no actual multiplication find how many digits there are in the integral part of the number represented by $9!^{9!^{9!}}$. Solution by the proposer.

Let $M = 9!^{9!^{9!}}$. Then $\log M = 9!^{9!} \times \log 9!$ (1)

Log $9! = 5.55976$ (By use of tables).

Again Let $N = 9!^{9!}$. Then $\log N = 9! \log 9! = T$. (2)

Now $\log T = \log 9! + \log (\log 9!) = 5.55976 + .74780$ (3)

$= 6.30756.$

Hence $T = 2030300$ and from (2) $N = 10^{2030300}$.

By substituting in (1)

$$M = 10^{2030300} \times \log 9!.$$

To find $\log 9!$, from (3), $\log (\log 9!) = .74780$.

Hence $\log 9! = 10^{.74780}$ and from (4)

$M = 10^{2030300.7478}$. Thus M consists of a number of 2030301 digits in its integral part.

Note: Other solutions misinterpreting the nature of the problem were offered. Editor.

1380. *Proposed by Maxwell Reade, Brooklyn.*

Evaluate

$$\sum_0^\infty \frac{(n+3)^2x^{n+2})}{(n+2)!}.$$

FIRST SOLUTION

Solution by W. E. Buker, Leetsdale High School, Leetsdale, Pa.

The ratio test shows that the series is convergent for all values of x.

$$e^x=1+x+\frac{x^2}{2!}+\frac{x^3}{3!}+\cdots$$

$$\therefore \quad xe^x=x+x^2+\frac{x^3}{2!}+\frac{x^4}{3!}+\cdots.$$

Differentiating,

$$e^x(x+1)=1+2x+\frac{3x^2}{2!}+\frac{4x^3}{3!}+\cdots$$

$$\therefore \quad xe^x(x+1)=x+2x^2+\frac{3x^3}{2!}+\frac{4x^4}{3!}+\cdots.$$

Differentiating again,

$$e^x(x^2+3x+1)=1+2^2x^2+\frac{3^2x^2}{2!}+\frac{4^2x^3}{3!}+\frac{5^2x^4}{4!}+\cdots$$

$$\therefore \quad e^x(x^2+3x+1)-4x-1=\frac{3^2x^2}{2!}+\frac{4^2x^3}{3!}+\frac{5^2x^4}{4!}+\cdots\frac{(n+3)^2x^{n+2}}{(n+2)!}+\cdots.$$

Hence

$$\sum_0^\infty \frac{(n+3)^2x^{n+2}}{(n+2)!}=e^x(x^2+3x+1)-4x-1.$$

SECOND SOLUTION

By Boris Garfinkel, Buffalo, N. Y.

The given series may be resolved into three series of the type $e^x=\sum_0^\infty \frac{x^n}{n!}$ by means of the identity $(n+3)^2=1+3(n+2)+(n+1)(n+2)$.

$$\therefore \quad \sum_0^\infty \frac{(n+3)^2x^{n+2}}{(n+2)!}=\sum_0^\infty \frac{x^{n+2}}{(n+2)!}+3x\sum_0^\infty \frac{x^{n+1}}{(n+1)!}+x^2\sum_0^\infty \frac{x^n}{n!}$$

$$=(e^x-x-1)+3x(e^x-1)+x^2e^x=e^x(x^2+3x+1)-4x-1.$$

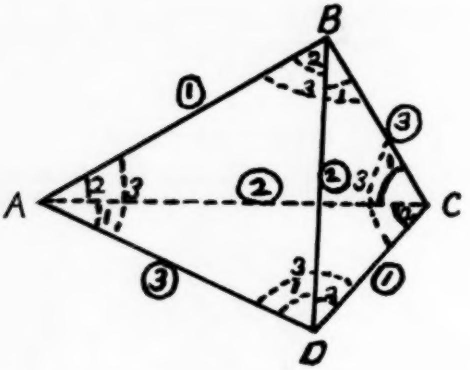
Solutions also submitted by Roy MacKay, Portales, N. Mex., Norman Anning, University of Michigan, Aaron Buchman, Buffalo, N. Y. and the proposer.

1381. *Proposed by Norman Anning, University of Michigan.*

In a tetrahedron $ABCD$, $AB=CD$, $AC=BD$, and $AD=BC$. Prove that all four of the solid angles are equal.

Solution by William Ashton, Mathematics Club, Olney H. S. Philadelphia.

Represent the equal sides in pairs by (1), (2) and (3). It follows that the four triangles are congruent, and that in the four triangles three angles of any one, designated by 1, 2, 3 are equal to corresponding angles of each of the others and designated by same notation.



Hence the trihedral angles at A, B, C and D are equal since the face angles are 1, 2 and 3. This is true since two trihedral angles are equal if the three face angles of one are equal respectively to the three face angles of the other and arranged in the same order.

Solutions were also offered by Boris Garfinkel, Buffalo, N. Y.; Roy MacKay, Portales, N. Mex.; W. E. Buker, Leetsdale, Pa.; Charles C. D'Amico, Albion, N. Y. and Margaret Joseph, Milwaukee.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1376. Exhram Kesolar, Marvin R. Ray, Arthur Kerr and Verle Reinsel—all of the Euler's 17 Mathematics Club, Corsica (Pa.) Union H. S., Fred Shirland, Math Club, Olney H. S. Philadelphia; Wallace B. McConnanghy, Lead, S. Dak. Sycamore (Ill.) H. S. Math. Club, Jean Scohy and Earl Parker of the Okmulgee (Okla.) H. S. and John Kalm, Lane Technical H. S., Chicago.

1378. Sycamore (Ill.) H. S. Math Club.

1394. *Proposed by Maxwell Reade, Brooklyn.*

Show that if a, b, c are positive and real

(a). $\frac{1}{2}(a+b+c)-\frac{ab}{a+b}-\frac{bc}{c+b}-\frac{ac}{c+a}$ can never be negative.

(b). For (a) to hold must a, b, c be real?

1395. *Proposed by Cecil B. Read, University of Wichita, Kansas.*

The sum of the squares of the segments of two perpendicular chords of a circle is equal to the square of the diameter.

1396. *Proposed by Norman Anning, University of Michigan.*

Arrange in descending order of magnitude, without finding numerical values, the following functions: cot 18°, csc 18°, 2 cot 36°, 2 csc 36°, 4 cos 36°.

1397. *Proposed by Richard A. Miller, University of Mississippi.*

In a triangle the circumradius is equal to the inradius divided by the sum of the cosines of the angles of the triangle diminished by 1.

1398. *Proposed by Julius Freilich, Brooklyn.*

Prove: $\cos 12 \cos 24 \cos 36 \cos 48 \cos 60 \cos 72 \cos 84 = (\frac{1}{2})^7$, the angular unit being the degree.

BOOKS AND PAMPHLETS RECEIVED

Daylight, Twilight, Darkness, and Time, by Lucia Carolyn Harrison, Department of Geography and Geology, Western State Teachers College, Kalamazoo, Michigan. Cloth. Pages viii+ 216. 13×19.5 cm. 1935. Silver Burdett and Company, 39 Division Street, Newark, New Jersey. Price $1.24.

An Introductory Course in College Physics, by Newton Henry Black, Assistant Professor of Physics, Harvard University and Redcliffe College. Cloth. Pages viii+714. 14×21.5 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.50.

The Principles of Heredity, by Laurence H. Snyder, Professor of Zoology, Ohio State University. Cloth. Pages xiii+385. 14.5×22.5 cm. 1935. D. C. Heath and Company, 285 Columbus Avenue, Boston, Massachusetts. Price $3.00.

Directions for the Dissection of the Cat, by Rovert Payne Bigelow, Professor of Zoology and Parasitology, Emeritus. Massachusetts Institute of Technology. Revised Edition. Cloth. Pages xi+65. 12.5×19 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 90 cents.

Mathematics in Life, by Ralph Schorling, Head of Department of Mathematics, The University High School and Professor of Education, University of Michigan, and John R. Clark, The Lincoln School, Teachers College, Columbia University. Kraft. Pages iv+44. 16×24 cm. 1935. World Book Company, Yonkers-on-Hudson, New York, Price 24 cents.

Beat Notes, Combinational Tones, and Sidebands, by Herbert Hazel, Indiana University, Bloomington, Indiana. 12 pages. 14×22 cm. Reprinted from the Philosophical Magazine, Ser. 7, Vol. xix. Page 103, January 1935.

On the Approval for Accreditment of College Science Laboratories, by N. M. Grier, Myerstown, Pennsylvania. 5 pages. 18×27 cm. Reprinted from Science Education, Vol. 19, No. 1, February, 1935.

Altes Und Neues Vom Kreis, von Dr. W. Lietzmann, Oberstudiendirektor/Honorarprofessor der Universität Göttingen. Paper. 11.5×18.5 cm. B. G. Teubner, Leipzig. Price R.M. 1.20.

In the Matter of A Proposed Reciprocal Trade Treaty Between The United States and Switzerland, Brief, by Francis P. Garvan. Paper. 124 pages. 15.5×23.5 cm. 1935. The Chemical Foundation Incorporated, 654 Madison Avenue, New York, N. Y.

The Investigation of Engineering Education and Related Activities by Charles F. Scott, Chairman, Board of Investigation and Coordination. Paper. Pages ii+37. 14.5×21.5 cm. 1934. F. L. Bishop, Secretary, Society for the Promotion of Engineering Education, University of Pittsburgh, Pittsburgh, Pa. Price 10 cents.

Chronographs and Accessories. Catalog B-1. 32 pages. 19×26 cm. 1935. The Gaertner Scientific Corporation, 1201 Wrightwood Avenue, Chicago, Illinois.

BOOK REVIEWS

Economic Geography by R. H. Whitbeck and V. C. Finch. Third Edition. 36 chapters, 565 pages, 163 maps, 122 graphs, 58 pictures, chapter references, 3½ pages general references, 12½ pages statistics, index. 1935. McGraw-Hill Book Company, Inc., New York and London. Price $3.50.

Economic Geography is presented in this volume upon a topical-regional basis at the level of beginning college classes. A background of physical geography is assumed as there is no separate treatment of climate or physiography as such, although the importance of the physical environment is stressed throughout the book.

This new edition is a most valuable addition to our field of economic geography. It is pleasing to the eye, the contents are clearly presented and are convincing, and the maps, graphs, statistical tables, and pictures add greatly to the value of this well written study of the worlds resources and human occupations.

The book is naturally divided into two parts. The first eighteen chapters make-up part one which treats of the United States and Canada. The similarity of these two countries in many respects and their close proximity permits them to be thoroughly discussed in these 265 pages. The order of presentation is logical and complete.

1. The Field of Modern Geography
2. Agriculture in the United States and Canada
3. Grain and Forage Crops
4. Vegetable Crops
5. Fruit Crops
6. Sugar, Vegetable Oils, and Tobacco
7. Vegetable Fibers and Textiles
8. Forest and Forest Product Industries
9. Animal Foodstuffs
10. Fisheries
11. Animal Fibers, Furs, and Skins
12. Fuel and Power
13. The Iron and Steel Industries
14. Mineral Industries
15. Inland Transportation
16. Foreign Trade and Transportation
17. The United States in the Pacific
18. Canada (A Summary)

The second part of the book covers the World Outside of the United States and Canada. The political divisions of the rest of the world are used instead of physical units. Each one is pleasingly presented and in most instances quite completely discussed. With special consideration to the materials suggested in the chapter references very fine studies could be made of all units. With the maps, pictures, and graphs carefully selected and well placed in each chapter a lasting picture is gained and a clear understanding is reached. Throughout the book the chapters are carefully divided into individual parts with distinct topic headings. Part 2 is presented in this order:

19. Mexico and the Caribbean Lands
20. The West Coast of South America
21. Argentina and Uruguay
22. Brazil and Paraguay

23. The Continent of Europe
24. Great Britain and Ireland
25. France and Belgium
26. West Central Europe
27. The Scandinavian Countries
28. Finland, Poland, and the Baltic States
29. Border Lands of the Mediterranean
30. Southeastern Europe
31. Russia
32. The Chinese Republic
33. Japan
34. Southern Asia and the East Indies
35. Africa
36. Australia and New Zealand

With the presentation of this edition of Economic Geography a fine tool has been brought up to-date for use in the field of economic geography and a better understanding of world commodity relations. This book would be most desirable as a college text. For the higher grades in high school and particularly for those students with a physical geography background it would be a splendid book for economic geography studies. Each college and high school library would find several copies of such a book a fine addition to the reference collection for work in economic, commercial, and industrial geography.

L. F. F.

Electrons (+ and −), Protons, Photons, Neutrons, and Cosmic Rays, by Robert Andrews Millikan, Formerly Professor of Physics at the University of Chicago, and now Director, Norman Bridge Laboratory of Physics, California Institute of Technology. Cloth. Pages x+492. 12.5×18.5 cm. 1935. University of Chicago Press, 5750 Ellis Avenue, Chicago, Illinois. Price $3.50.

In 1917 Dr. Millikan published the first edition of "The Electron." Further developments demanded additions which were made in 1924. The present volume retains practically all of the content of the former editions with only minor changes. The results of the investigations previously reported have stood the test and are the foundations for more recent experiments which are critically examined in the present volume. This book is now the best available introduction to the study of the recent investigations in this branch of physics. Beginning college students and educated laymen can follow the author through this interesting account of the delicate and accurate experiments that determine the electron charge, produce the evidence for the present theories of atomic structure, investigate the nature of radiant energy, and demand spinning electrons. The chapter on waves and particles is the best short essay on this subject to be found anywhere. Much of the new material deals with the discovery of the cosmic rays, their nature and origin; also the discovery of the neutron and the positron.

This book brings the reader into direct contact with a master of investigation. As he reads he gets the impression that Millikan is there talking to him. He unconsciously examines the evidence presented and learns to think in the manner of a scientist. The many illustrations, especially those showing the tracks made by various particles, give him an appreciation of the tangible evidence which forms the basis for modern theory.

G. W. W.

Before the Dawn of History, by Charles R. Knight. Cloth. Pages xiii+119. 23×30 cm. 1935. Published by Whittlesey House, McGraw-Hill Building. 330 West 42nd Street, New York, N. Y. Price $2.50.

A subject more interesting to scientist or layman than the title of this book could scarcely be announced. It stimulates the imagination of all ages and classes. In this book it is presented in pictorial form by a master of the subject and a famous artist. His work in the American Museum of Natural History, the Field Museum, and the Los Angeles Museum has won him a world-wide reputation for presenting pre-historic scenes. He now brings these scenes into the library and home. The book contains forty-four pages of pictures depicting scenery of plant and animal life, as interpreted from fossil records, from before the dawn of life to the polished-stone-age. Each illustration is described and explained on the page facing the picture. In addition there are thirty more pages of print which tell about the types of fossils that have been found and how the knowledge of prehistoric time has been built up. The book is a very attractive gift book for your friends, old or young, educated or uninformed.

G. W. W.

Science in the New Education, by S. R. Slavson, Research Director, Malting House School, Cambridge, England, formerly The Walden School, New York, and Robert K. Speer, Professor of Education, New York University. 384 pages. Cloth. Prentice-Hall and Co. $2.50. 1934.

Science in the New Education comes as a very stimulating and thought provoking book. It presents admirably the new point of view in progressive education. It treats the problems of science instruction in the elementary school with clarity and understanding.

The book gives the results of a thorough investigation over a period of several years of the interests and activities of children in the Walden School by the use of the search-discovery method. According to the authors "the search-discovery technique is not a formalized, defined method; it is an approach to the conditions under which learning takes place, through the utilization of the psycho-organic drives of the child."

The search-discovery method demonstrates clearly that children in the earlier years are as much interested, if not more so, in the physical sciences as they are in the biological sciences. The physical science materials give them more opportunity to exercise their activity and power drives. The results of the authors' investigations contradict many of the other investigations which have been conducted to determine the interests of children.

Some chapters in the book not found in most science methods books of this nature are: "Trends in Elementary Education," "Nature of Children's Scientific Interests," "Determining Children's Scientific Interests," "Interest Studies Based on Free Activity," "Individual Objectives in Science Education," "Social Objectives of Science Education," and "The Search-Discovery Method."

This book provides for teachers of science a basic philosophy of teaching founded on the activities and interests of children.

Ira C. Davis

Second-Year Algebra by Herbert E. Hawkes, Ph.D. Professor of Mathematics in Columbia University, William A. Luby, A.M., Head of the Department of Mathematics in the University of Kansas City, and Frank C. Touton, Ph.D., Professor of Education in the University of Southern California. Pages vii–360. 1935. Ginn and Company, Chicago. Price $1.24.

This text is a revision of the brief edition of the authors' New Second Course in Algebra and includes material to cover a standard third semester's work in the subject. Some of the features of the book are an abundance of simple exercises for a review of first year algebra, a summary and a set of review questions at the end of each chapter, and a group of additional exercises and problems provided at the end of the book and divided according to chapters to which the material applies. The function concept is emphasized in two chapters under the headings of "Variation" and "Functions and Graphs." The exercises in the latter chapter call for the graphing of statistical data as well as functions. The authors emphasize the distinction between functional graphs and those that are nonfunctional or dislay graphs. One chapter is devoted to logarithms and one to an introduction to trigonometry. A sample of the new type examinations covering twelve pages is given in the back of the book. As in the case of their other texts the authors give a careful development of each new topic and furnish an ample supply of exercises graded as to difficulty. Teachers of algebra will be interested in examining this new book.

The authors state in the preface that they have also prepared an Enlarged Edition of this text, which covers several additional topics, to meet the needs of those who wish to devote a full year to the second course in algebra.

G. E. Hawkins

The Arithmetic of Business, by Frank J. McMackin, Principal, William L. Dickinson High School, Jersey City, John A. Marsh, Head of Mathematics Department, High School of Commerce, Boston and Charles E. Baten, Instructor in the Commercial Department, The Lewis and Clark High School, Spokane. Ginn and Company, 1934. Pp. IX+486.

This text is designed for students of arithmetic who are interested in business. The material covers many important phases of business, which the pupils learn thoroughly while getting practice in the fundamental processes of arithmetic.

The units are concise and well organized. The book contains an abundance of exercises graded according to difficulty into three classes. Review exercises are placed at appropriate places and at the end of each chapter are achievement tests and cumulative drill exercises.

Diagnostic tests to be used in conjunction with the review work are published as a separate pamphlet.

The book should be of interest to commercial teachers and to those who teach or plan to teach Business Arithmetic.

Samuel Josephs

Mastery Arithmetic, Book One and Book Two, by George R. Bodley, Charles S. Gibson, Ina M. Hayes, and Bruce M. Watson. D. C. Heath and Company, 1934. Pp. viii+336 and x+390.

These books present courses in arithmetic for Grades Three to Six. The material outlined for Grade Three presents the four processes with numbers to four places, including multiplication by a two-place number and division by a one-place number. The material for Grade Four includes study of numbers to nine places, long division by a two-place number, and addition and subtraction of similar and dissimilar fractions. In Grade Five are taught multiplication and division of fractions and the four processes with decimals. The material for Grade Six includes all three cases in percentage and applications including discount, commission, and interest. For each grade there is provided thorough review and extension

of the processes taught in the previous grade, which may make the books adaptable to the needs of schools whose courses are less ambitious than the one provided here.

The books have several distinctive features. Unusual emphasis is given to the relation of factors and product. This relation has been used by other authors in teaching percentage but in the present work it is also used for introducing division of fractions. The importance of zero as a place holder is presented in Grade Five in a way which should effect better understanding and increased appreciation of our number system. An attempt is made to relate arithmetic to other studies by providing groups of problems from geography and from history. There is provided a series of "mental tests," in which the pupil is directed to write only the answers to examples and problems, all computation being done mentally. This is a feature which will probably be favorably received by many who believe our pupils are too dependent upon written procedures to apply arithmetic effectively in later courses and in out-of-school situations.

LENORE JOHN

Das Spiel der 30 bunten Wurfel (*The Game of the 30 Colored Cubes*), *MacMahons Problem*, by Dr. Ing. Ferdinand Winter, Society of German Engineers, Dresden. Paper 128 pp. 14×20.2 cm. 31 figures, 27 tables. B. G. Teubner, Leipzig and Berlin, 1934. Price: RM 3.60.

Major MacMahon's problem involves 30 cubes, each having a yellow, black, blue, red, green, and white surface. On each of the 30 cubes the colored surfaces are in a different relation. The problem: Choose any one cube as a model. Using 8 of the remaining 29 cubes, make a large cube whose surfaces correspond in color to the model cube. The inner surfaces of the chosen eight small cubes must correspond in color to the surfaces they face.

The author of this book points out that there are 60 possible arrangements, i.e., two for each of the 30 cubes as a model, and that Dr. Kowalewski (*Alte und neue mathematische Spiele*, Teubner, Leipzig, 1930) has already exhaustively developed a theory for the solution. Dr. Winter continues a development of the problem, expanding its possibilities as a mathematical pastime. He simplifies the theory of the study. He also facilitates the manipulation of the cubes by color-striping the edges of each square surface of the cubes so that the color of all six surfaces may be known without reversing the block. These color squares with edges of four different colors lead the author to substitute square plates for the cubes, which reveals to him many new possibilities for problem plays, among them *color domino*, a highly variable game.

Although this book takes up MacMahon's problem where others left off, it also serves as an introduction to this mathematical pastime. It states the original problem and discusses the contributions of Dr. Kowalewski. The suggestions of the latter as to how one may color a "home-made" set of cubes, are given in detail. The set of cubes, conveniently numbered and lettered are obtainable from S. F. Fischer, Baukastenfabrik, Oberseiffenbach i. Erzg.; also through toy or book dealers.

A. H. THOMAS

HOW MANY TEACHERS?

There are approximately 1,063,000 teachers in all types of schools in the United States. About 700,000 of these are in elementary schools, about 250,000 in secondary schools, and about 90,000 in colleges.

THE FIFTIETH ANNIVERSARY OF SILVER, BURDETT AND COMPANY

On April 21, 1885, Mr. Edgar O. Silver engaged in the publication of textbooks at 50 Bromfield Street, Boston. Thus 1935 marks the Fiftieth Anniversary of the company founded by Mr. Silver and incorporated in 1892 under the name of Silver, Burdett and Company. A brief review of various activities in the life of the company discloses both educational attainments and ideals.

At the 1935 meeting of the Department of Superintendence of the National Education Association at Atlantic City, the company exhibited a number of objects of intimate historical interest. Mr. Silver's original office desk, at which in 1895 Dr. Samuel Francis Smith, author of "My Country 'Tis of Thee," autographed copies of his "Poems of Home and Country," was the central point of the exhibit. A copy of the autographed book itself and Dr. Smith's picture as he sat at the desk attracted considerable attention. A number of the early publications of the House were interestingly displayed. Among the medals on display was the award from the Paris Exposition of 1900 for "Stepping Stones to Literature," the pioneer eight-book series of literary readers in America.

November, 1909, brought an abrupt ending of Mr. Silver's career through illness which came without warning and lasted but a few days. Practically one-half of the life of the company was under his guidance. Three men have succeeded him as executives of the company: Mr. Arthur Lord, of Boston, 1910–1914; Mr. Haviland Stevenson, 1914–1927; and since 1927, Mr. George L. Buck.

During the quarter century in which Mr. Silver directed the affairs of the company, it might be said that the textbook industry crystallized its form as a factor in American education. Possibly the younger generation of educators do not stop to realize the extent of influence in American education exerted by a group of men who, during the period referred to, were recognized for leadership in an industry which in many respects was finding its place as a new influence on American life. No attempt is made to catalogue with exaction the names comprising this group, but certainly included in such a group would be such men as Edwin Ginn, Dr. George A. Bacon, Daniel C. Heath, Henry Holt, Charles E. Merrill, and Edgar O. Silver. It would be interesting to trace the imprint of such men as these upon the subsequent policies of the respective organizations they served.

As a feature of its commemoration of fifty years of publishing school and college textbooks and with the thought of giving—and in some measure with the thought of memorializing—the type of interest and purpose so clearly exemplified by the policies of its founder, the company has commissioned the internationally-known painter, N. C. Wyeth, to create a symbolic mural painting entitled "The Spirit of Education." The canvas shows a majestic figure, a goddess of hope and inspiration, leading a phalanx of children through the educational eras from the first Colonial schools to the present day. In the brilliant and appealing style of the artist, the background reveals the historic transformation of America from the primeval forest to the stacks and skyscrapers of our modern industrial cities. A reproduction of this mural in six colors will be prepared and, upon request, will be sent to schools and educators who may be interested in this conception, both as an artistic decoration and as a subject of contemplation when present-day confusion and contradictions beset the planning of educators and challenge their action.

ACTIVE PRINCIPLE OF ERGOT, WIDELY USED IN CHILDBIRTH, ISOLATED

The active principle of ergot, a drug once widely used in childbirth, has been isolated by H. W. Dudley, biochemist of the Medical Research Council and Dr. Chassar Moir, London University gynecologist.

Scientists have long sought to find the substance in ergot which is responsible for its effect on the uterus. The success in this search, just reported by Dr. Moir and Mr. Dudley to the British Medical Journal, marks the culmination of a three-year alliance of chemistry and clinical medicine.

Ergometrine is the name of the newly-isolated substance. When given by mouth, it produces strong contractions of the uterus after eight minutes. Hypodermic injections start the contractions within four minutes, on the average.

Ergometrine belongs to the class of drugs known as alkaloids. It differs markedly from and is probably simpler than other alkaloids isolated from ergot which were thought previously to be responsible for the drug's action on the childbearing organ. These are now finally proved not to be responsible for the drug's action.

The results obtained by the English scientists are said to be in accord with the findings of an American scientist, Dr. A. K. Koff of Johns Hopkins Medical School.

OLDEST PHOTOGRAPHIC TELESCOPE RE-USED TO SHOW PLEIADES AS SCATTERING CONSTELLATION

The Pleiades, or "Seven Sisters," are not so sisterly as their name might indicate. New measurements with the world's oldest photographic telescope show them to be moving apart, going their separate ways, despite current astronomical ideas to the contrary.

This discovery was announced by Prof. Jan Schilt, of the Columbia University department of astronomy. It is the result of the comparison of photographic plates made 67 years ago with similar plates made recently. The angular motion between the six visible and many lower-magnitude stars composing this familiar group is so small, however, that Prof. Schilt likened it to the movement in 100,000 years by an insect on 42d Street as it would appear to an observer on top of the Chrysler Building.

To make the new set of plates duplicate the old as nearly as possible, Prof. Schilt resurrected from a museum the old telescope originally used. It was made in 1868 by a Mr. Rutherfurd, an old-time trustee of Columbia University, and had long since been retired from use. However, with a new plate holder and specially made plates to give as nearly as possible the same effects as the old plates, it functions as well as ever.—*Science Service.*